ORIGINAL ARTICLE

Different Positions of Facial Nerve in Relation to Cochlear Implant and Its Impact on Postoperative Facial Nerve Paralysis

Ali K. Mahrous, Marwan A. Ibrahim, Hussein O. Hussein*

Department of Otolaryngology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: ***A rate of 1–3% was reported for facial nerve (FN) paralysis as a complication of cochlear implant surgery. This complication may be prevented by understanding the anatomical relationship of the FN with a variety of adjacent landmarks in the surgical field. The aim of this work was to find out the impact of facial recess width on FN function after cochlear implantation.***

Methods: ***This was a retrospective cohort study that carried on 200 patients who underwent cochlear implantation (CI) through a trans mastoid facial recess (FR) approach. Study subjects were compared according to FN paralysis occurrence in relation to age, gender and FR width.***

Results: ***The relationship between FR width and age revealed a trend of increasing FR width with age. The relationship between FR width and gender showed a minimal variation between females and males. For all subjects, there is a very weak positive correlation between FR width and age. In the subgroup with FN paralysis, the relationship showed a slightly positive correlation. Similarly, in the subgroup without FN paralysis, the relationship remains very weak with a positive correlation. Females and males showed an almost negligible and positive correlation between FR width and age, suggesting no significant relationship.***

Conclusions: ***There was a low incidence of FN paralysis, with generally favorable outcomes in terms of recovery time. While there was a trend of increasing FR width with age, this relationship was not statistically significant. FR width did not appear to be associated with the occurrence of FN paralysis.***

Keywords: Cochlear Implant; Facial Nerve Paralysis ; Facial Nerve

1. Introduction

Cochlear implantation (CI) is a treatment option that is widely acknowledged for individuals with severe to profound hearing loss who do not receive sufficient benefit from amplification. CI is a surgical technique that is generally considered to be safe, with an overall significant complication rate of approximately 2.3% to 8%. Despite its rarity, iatrogenic facial nerve (FN) paralysis is one of the most severe postoperative complications of CI surgery, with an incidence of 0.67% to 1.2% .[1]

Cochlear implants (CIs) stimulate the auditory nerve through a sequence of electric pulses to facilitate sound perception .[2]

The most prevalent method for CI is the mastoid process (facial recess (FR) approach). The key to this operation is to open the FR, expose the posterior tympanum, locate the round window niche and round window membrane, accurately locate the scala tympani, open the round window membrane, and insert the electrode into the cochlear scala tympani without causing any injury. Although the FN, chorda tympani nerve, and other critical structures are susceptible to injury during the operation if the FR is narrow .[3]

The complications of CI can be categorized as either "major" (e.g., wound flap necrosis, meningitis, electrode misplacement, implant extrusion, magnet displacement) or "minor" (e.g., transient postoperative facial weakness, acute otitis media, dizziness, intraoperative bleeding, FN stimulation, postoperative pain, and several others). The classification as major or minor is determined by the necessity for additional surgery or outpatient methods .[4]

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* Corresponding author at: Otolaryngology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt.
E-mail address: hosseinomar87@gmail.com (H. O. Hussein).

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The FN is susceptible to injury during CI, particularly during posterior tympanotomy, due to its anatomical location. A narrow FR or an insufficient posterior tympanotomy may result in injury to the FN chorda tympani nerve and mastoid segment. This complication is typically the result of a limited understanding of the anatomy of the FR and various mastoid segment anomalies. Consequently, it is crucial to conduct a radiological anatomy assessment, FN course anomalies, and anatomical factors that may influence the field of view or accessibility of the posterior tympanotomy in order to reduce the nerve injury risk .[5]

Complications of cochlear implant surgery were reported to occur at a rate of 1-3%, including FN paralysis. This complication may be prevented by an understanding of the anatomical relationship between the FN and a variety of adjacent landmarks in the surgical field .[6]

We aimed to assess the effect of different FN positions in relation to cochlear implant and its impact on postoperative FN paralysis.

2. Patients and methods

This retrospective analysis reviewed the medical records and radiologic findings of 200 patients who underwent CI through a trans mastoid FR approach between January 2018 and December 2022. These patients were operated on at two centers: the Insurance Hospital in Elminia and Al-Azhar University Hospitals, with each hospital contributing 100 cases to the study.

Inclusion Criteria

Surgical Procedure: Patients who underwent CI using the transmastoid FR approach, a commonly used technique for exposing the round window while minimizing trauma to the FN.

Time Frame: Patients who had their surgeries performed between January 2018 and December 2022. This period allows for the inclusion of recent cases with complete postoperative follow-up data.

Data Completeness: Only patients with complete and accessible medical records and radiologic findings, computed tomography (CT), will be included. This ensures that all necessary data for evaluating the FN's position and postoperative outcomes are available for analysis.

Exclusion Criteria

Incomplete Data: Patients with incomplete or missing medical records or radiologic findings will be excluded, as these gaps could lead to inaccuracies in assessing the outcomes and complications.

Different Hospitals: Patients who underwent surgery at hospitals other than the Insurance Hospital in Elminia and Al-Azhar University Hospitals will be excluded to maintain consistency in surgical techniques and postoperative care, which could vary significantly across different institutions.

The investigation was conducted with the approval of the Ethical Committee of Al-Azhar University Hospitals. The patients provided written informed consent.

Data Collection

Patient Demographics: Age was recorded at the time of surgery and categorized into age groups for analysis. Gender was documented to identify gender-specific differences in outcomes. A detailed history, including past conditions, previous surgeries, and family history, was collected, with a focus on conditions influencing surgical outcomes or recovery.

Clinical Presentation: Preoperative Hearing Status: Information on the degree of hearing loss was documented, including results from audiometric tests. Any congenital anomalies identified during preoperative assessments and comorbid conditions present in the patients was recorded.

Intraoperative Findings

Detailed documentation of the surgical approach used for each patient, specifically noting any deviations from the standard transmastoid FR approach.

Variations in the anatomical position of the FN encountered and any complications that occur during the surgery were meticulously recorded.

Postoperative Outcomes

FN Paralysis Onset: The onset time of any FN paralysis post-surgery was noted, whether it occurred immediately postoperatively or developed later.

Severity of Paralysis: The severity of FN paralysis was graded using the House-Brackmann (HB) grading system, ranging from Grade I (normal function) to Grade VI (complete paralysis).

Management and Interventions: All management strategies and interventions used to address FN paralysis were recorded.

Definitive Outcomes: The final outcomes of the FN paralysis, including recovery status at follow-up visits, were documented.

5. Radiologic Findings (Preoperative Imaging):

Detailed evaluation of preoperative CT scans was conducted to assess FR width and the anatomical course of the FN.

Procedures

Implementation Steps

Retrospective Review of Patient Records and Imaging:

Identification and selection of patients who underwent CI through the transmastoid FR approach. This involved retrieving surgical records, preoperative and postoperative clinical notes, and imaging reports.

Extraction of detailed data from the selected

patient records, including demographics, clinical presentation, intraoperative findings, postoperative outcomes, and radiologic findings.

Identification and Documentation of FN Paralysis Cases:

Clinical Assessment: review of postoperative clinical assessments to identify cases of FN paralysis. Each identified case was documented in detail. Correlation of clinical findings with radiological imaging to confirm the relation between radiological measurement of FR width and postoperative FN paralysis.

Outcome Measures

Primary Outcome Measure: The primary outcome measure focuses on the incidence and severity of postoperative FN paralysis in cochlear implant. This was meticulously documented using the HB grading system, which is a widely standard scale for assessing FN function.

Incidence of Postoperative FN Paralysis

The postoperative FN paralysis incidence was calculated by dividing the number of patients who developed paralysis after CI by the total number of patients in the study. Regular assessments were conducted at various intervals to monitor for signs of paralysis. Each case was documented, including the time of onset, progression, and any interventions used.

Severity of Postoperative FN Paralysis:

HB Grading System: the severity of FN paralysis was graded utilizing the HB grading system, which categorizes FN function into six grades as:

Grade I: Normal facial function in all areas

Grade II: Mild dysfunction (slight weakness noticeable only on close inspection)

Grade III: Moderate dysfunction (clear but not disfiguring difference between the two sides; noticeable but not severe synkinesis, contracture, or hemifacial spasm)

Grade IV: Moderately severe dysfunction (clear disfiguring asymmetry)

Grade V: Severe dysfunction (only barely perceptible motion)

Grade VI: Total paralysis (no movement)

FN function was evaluated at each follow- up visit using the HB grading system. The final grade at the last follow-up visit was used to determine the long-term severity of FN paralysis for each patient.

Secondary Outcome Measures

The secondary outcome measure examines the correlation between the FR width in axial high-resolution CT by measuring the distance between the chorda tympani posterior canaliculus (maximum distance) and FN vertical portion the with age and gender, of 200 patients who underwent cochlear implant through transmastoid FR approach and occurrence of postoperative FN paralysis.

CT Protocol of the Study

The patient was put in the supine position on the CT scanner table. High-resolution imaging was used to capture detailed images of the petrous region. Select the appropriate field of view (FOV) to focus on the area of interest.

Tube voltage (KV): typically used a voltage between 120-140 KV for a petrous CT scan. Scanner with an FOV of 14-16 cm and a slice thickness of 0.625 mm and a pitch of 1 or lower was suitable for high resolution imaging.

Statistical analysis

SPSS v25 (IBM Inc., Armonk, NY, USA) was employed to conduct the statistical analysis. The same group's quantitative variables were contrasted utilizing the Student's t-test; the mean and standard deviation (SD) were presented. Frequency and percentage (%) were employed to represent qualitative variables. Normal data distribution was detected using the Shapiro-Wilk test. A two-tailed P value of < 0.05 was regarded as statistically significant.

3. Results

The mean age of the patients was 4.38 ± 2.16 years, with a median age of four years, spanning from 1.5 to 16 years. Notably, 96% of the patients were under 6 years old, the age group of 7-9 years old made up 1% of the cohort, while only 1% were aged 9-12 years and 2% were over 12 years old. Out of the total subjects, 54% (108 patients) were female, while 46% (92 patients) were male. Table 1

The FR mean width was 4.52 ± 0.93 mm. The median FR width is 4.39 mm, with a range extending from 2.50 mm to 6.80 mm. Only 3.5% (7 patients) experienced FN paralysis postoperatively, while the vast majority, 96.5% (193 patients), did not encounter this complication.

Table 1. Distribution of age and gender of the studied subjects.

		TOTAL SUBJECTS, N=200	
		Mean ± SD	MEDIAN (MIN-MAX)
AGE (YEARS)		4.38 ± 2.16	4.00 (1.50-16.00)
		N	%
AGE (GROUPS)	≤ 6 years old	192	96.0%
	7-9 years old	2	1.0%
	9-12 years old	2	1.0%
	>12 years old	4	2.0%
GENDER	Female	108	54.0%
	MALE	92	46.0%

Data are presented as mean ± SD or number (%).

Among the seven patients who experienced FN paralysis following CI, the distribution of HB grading shows that the majority had moderate FN dysfunction. Specifically, 71% (5 patients) were classified as HB Grade III, indicating

moderate dysfunction, while 29% (2 patients) were classified as HB Grade IV, indicating moderately severe dysfunction. Table 2

Table 2. FR width and FN paralysis occurrence among study subjects.

TOTAL SUBJECTS, N=200			
FR WIDTH (MM)		4.52 ± 0.93	4.39 (2.50-6.80)
FN	FN paralysis	7	3.5%
	NO FN PARALYSIS	193	96.5%

Data are presented as mean SD or number (%). FR: facial recess, FN: facial nerve.

The recovery time for FN paralysis showed a mean duration of 2 ± 1 months. The median recovery time was 2 months, with a range from 1 to 4 months. Onset of paresis for FN paralysis showed a mean duration of 4.43 ± 2.23 days. Table 3

Table 3. HB grading, recovery time, onset of paresis in FN paralysis subjects.

FN PARALYSIS, N=7			
HB GRADE	III	5.0	71%
	IV	2.0	29%
RECOVERY (MONTHS)		2 ± 1	2 (1-4)
ONSET OF PARESIS (DAYS)		4.43 ± 2.23	5 (2-8)

Data are presented as mean ± SD number (%), or median (IQR). FN: facial nerve, HB: House-Brackmann.

The relationship between FR width and age among the study subjects reveals a trend of increasing FR width with age. For children under 6 years old, the mean FR width is 4.47 mm with a SD of 0.91 mm. In the age group of 7-9 years old, the mean width increases to 5.04 mm with a SD of 0.00 mm. This trend continues for children aged 9-12 years old, with a mean FR width of 5.73 mm and a SD of 0.95 mm. For patients older than 12 years, the mean FR width reaches 5.82 mm, with a SD of 0.92 mm. The relationship between FR width and gender among study subjects shows minimal variation between females and males. The mean FR width for females is 4.58 mm with a SD of 0.94 mm, while for males, the mean FR width is slightly lower at 4.43 mm with a SD of 0.91 mm. Table 4

Table 4. Relation between FR width and age, gender.

TOTAL SUBJECTS, N=200			
		Mean	SD
AGE (GROUPS)	≤6 years old	4.47	0.91
	7-9 years old	5.04	0.00
	9-12 years old	5.73	0.95
	>12 years old	5.82	0.92
GENDER	Female	4.58	0.94
	MALE	4.43	0.91

Data are presented as mean ± SD or number (%).

The relationship between FR width and the occurrence FN paralysis among study subjects reveals no significant difference between the FN paralysis and no FN paralysis groups. Specifically, the mean FR width in patients with FN paralysis is 4.69 ± 0.99 mm, with a median width of 4.52 mm (ranging from 3.18 to 5.95 mm). In contrast, the mean FR width in patients without FN paralysis is 4.51 ± 0.93 mm, with a median width of 4.38 mm (ranging from 2.50 to 6.80 mm). Table 5

Table 5. Relation between FR width and FN paralysis.

		FN PARALYSIS N=7	NO FN PARALYSIS N=193	TEST RESULT
FR WIDTH	Mean ± SD	4.69 ± 0.99	4.51 ± 0.93	T: 1.292, P=0.198
	MEDIAN (MIN-MAX)	4.52 (3.18-5.95)	4.38 (2.50-6.80)	

Data are presented as mean ± SD or median IQR. FR: facial recess, FN: facial nerve.

The correlation analysis between FR width and age among study subjects shows no significant relationship. For all subjects, there is a very weak positive correlation between FR width and age. Table 6

Table 6: Correlation between FR width and age among study subjects.

ALL SUBJECTS		
	r	P
AGE	0.076	283

r: Spearman correlation coefficient

In the subgroup with FN paralysis, the relationship shows a slightly positive correlation. Similarly, in the subgroup without FN paralysis, the relationship remains very weak with a positive correlation. Overall, these results suggest that age does not significantly impact the FR width, regardless of whether FN paralysis occurs. Table 7

Table 7. Correlation between FR width and age according to FN paralysis among study subjects.

	FN PARALYSIS		NO FN PARALYSIS	
	r	p	r	P
AGE	0.491	0.263	0.044	0.548

r: Spearman correlation coefficient, FN: Facial nerve.

When analysed by gender, females and males shows an almost negligible and positive correlation between FR width and age, suggesting no significant relationship. Table 8

Table 8. Correlation between FR width and age according to gender among study subjects.

	FEMALE		MALE	
	r	p	r	P
AGE	0.084	0.388	0.006	0.952

r: Spearman correlation coefficient

4. Discussion

Despite the fact that CI is regarded as a secure method of rehabilitation for profoundly deaf individuals, a number of these patients experience complications following the surgery. Major surgical complications necessitate additional surgery or hospitalization, while minor complications can be resolved with treatment in an outpatient ward or without treatment at all. Minor complications include FN stimulation, electrode migration, vertigo, tinnitus, and others, while major complications include meningitis, flap necrosis, device failure, electrode extrusion, and FN paralysis .[7]

In the present study, it was found that the mean age of the patients was 4.38 ± 2.16 years, with a median age of 4 years, spanning from 1.5 to 16 years. Notably, 96% of the patients were under 6 years old, the age group of 7 - 9 years old made up 1% of the cohort, while only 1% were aged 9-12 years, and 2% were over 12 years old. There was a slight predominance of 54% (108 patients) females over 46% (92 patients) males.

Behairy et al.[8] results showed that females were the most predominant gender among the study group were 56 (56.0%) females and 44 (44.0%) males with an age range from 1.7 to 33 years.

Hsieh et al. [9] results showed that 299 females and 346 males were involved in the study, with a mean age of 8.3±12.3 years (range 1.0 – 74.1 years).

In the present study, it was found that the mean width of 4.52 ± 0.93 mm. The median FR width is 4.39 mm, with a range extending from 2.50 mm to 6.80 mm.

Behairy et al.[8] highlighted that the mean FR width surgically was 4.44 ± 0.86 mm SD with a range of 2.2- 6.45. These findings agreed with Ohira et al.[10] who indicated that the canal skin was preserved, and the bone of the medial external auditory canal was translocated anteriorly along with its attached skin to enhance visualization of the round window. In cases where the FR width was less than 3 mm, the posterior external auditory canal wall was mobilized using a 0.5 mm bur superiorly at the attic and inferiorly just below the round window. Canal walls were repaired with bone paste.

The high-resolution MRI and CT findings of patients who were being detected preoperatively for CI were graded on a 10-point scale by Vaid et al.[11] A narrow FR of less than 3 mm was deemed unfavorable, while a wide FR of more than 3 mm was deemed favorable. FR anatomy was regarded as one of the parameters of difficulty encountered during CI.

This is in accordance with the results of the study conducted by Bettman et al.[12] in which preoperative temporal bone CT scans were contrasted to the findings at the surgery to assess the dimensions of the FR and the relationship between the FR and the cochlea. They discovered that the mean FR width at the round window level was 4.5 mm, with a standard deviation of 1.3 mm.

In the present study, it was found that only 3.5% (7 patients) experienced FN paralysis postoperatively, while the vast majority, 96.5% (193 patients), did not encounter this complication.

Cosetti and Roland[13] indicated that 16.1% of the group under investigation experienced significant complications. CSOM was the least prevalent complication (0.8%) for each, followed by magnet migration (2.3%), CSF leak (6.1%), total FN paralysis (3.8%), and electrode extrusion and device failure (1.5%). In five patients, transient FN paralysis occurred. The patients underwent medical treatment, and all of them experienced an improvement in their facial function within three months of the operation.

In the present study, it was found that among the seven patients who experienced FN ve paralysis following CI, the distribution of HB grading shows that the majority had moderate FN dysfunction. Specifically, 71% (5 patients) were categorized as HB Grade III, indicating moderate dysfunction, while 29% (2 patients) were categorized as HB Grade IV, indicating moderately severe dysfunction.

In Thom's study,[14] 888 CI surgeries (282 pediatric, 606 adult; 851 primaries, 37 revision) were examined in 768 patients. Of these, 11 patients (two pediatric and nine adult) developed postoperative FN paresis within three weeks of surgery and were involved. Ten patients (1.1%) exhibited delayed onset paresis and achieved complete recovery (HB grade 1) within six months of surgery. Conversely, a single patient (0.1%) developed immediate onset paresis and experienced incomplete recovery (HB grade 2) one year after surgery.

Orlando and Cruz,[15] revealed that four patients experienced alterations in facial mimicry (2.1%), with three patients experiencing complete regression and one patient remaining with House Brackmann (HB) grade 4 paresis. Extra auditory sensation with facial muscle spasms was reported by two patients (1.0%).

In the present study, it was found that recovery time for the seven patients who experienced FN paralysis following CI shows a mean duration of 2 ± 1 months. The median recovery time is 2 months, with a range from 1 to 4 months. Onset of paresis for the seven patients who experienced FN paralysis following CI shows a mean duration of 4.43 ± 2.23 days.

Thom et al.[14] stated that the 10 delayed onset FN paresis patients completed FN recovery (HB grade 1) on average in 2 months (range, 3 weeks - 6 months), with a mean onset of 8.8 days (range,

3-16 days) following surgery.

In the present study, it was found that the relationship between FR width and age, gender, and FN paralysis was discovered among the study subjects, revealing a trend of increasing FR width with age, a minimal variation between females and males, and an insignificant difference between the FN paralysis and non-FN paralysis groups. In the subset with FN paralysis, there is a modest positive connection. Similarly, in the subgroup without FN paralysis, the association is still very modest, with a positive correlation. A correlation analysis of FR width and age among research respondents reveals no significant link. Females and males have a nearly minimal and positive association between FR width and age, indicating no significant link.

Behairy et al.[8] revealed that the p-value was less than 0.0001, indicating a significant correlation between the FR length measured surgically and the FR length measured radiologically (CT oblique sagittal plane and curved MPR CT). Therefore, the intraoperative measurement can be predicted using radiological measurements. Surgically and radiologically, no significant correlation was found between age and the FR measurements (length and width).

4. Conclusion

This study on pediatric cochlear implant patients demonstrated a low incidence of FN paralysis, with generally favorable outcomes in terms of recovery time. While there was a trend of increasing FR width with age, this relationship was not statistically significant. FR width did not appear to be associated with the occurrence of FN paralysis.

Disclosure

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All authors have a substantial contribution to the article

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