

Original Article

Evaluation of the Relationship Between Facial Nerve and Lateral Semicircular Canal in the Posterior Tympanotomy Approach

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BACKGROUND: To clinically and radiologically evaluate the relationship between the facial nerve and the lateral semicircular canal during posterior tympanotomy.

METHODS: Patients who received cochlear implants between 2010 and 2020 were included in the study. The relationship between the facial nerve and the lateral semicircular canal was classified into 3 types by evaluating the axial section computed tomography images. If the facial nerve passed medially without contacting the lateral semicircular canal dome, it was classified as type 1; if the facial nerve passed by contacting the medial border of the lateral semicircular canal dome, it was classified as type 2; and if the facial nerve contacted the lateral border of the lateral semicircular canal dome or passed more laterally, it was classified as type 3.

RESULTS: In total, 309 ears of 257 patients [139 males (54.1%) and 118 females (45.9%)] were included in the study. Ninety-three (30.1%) of the ears were classified as type 1, 179 (57.9%) were type 2, and 37 (12%) were type 3. It was found that the combined posterior tympanotomy/endomeatal approach was used in 6 ears (1.9%), of which 4 were type 3, and 2 were type 2 ($P = .006$).

CONCLUSION: Systematic evaluation of the relationship between facial nerve and lateral semicircular canal in computed tomography axial sections might help prevent facial nerve damage that can occur during posterior tympanotomy. It was concluded that type 3 ears should be evaluated in this respect, as a combined posterior tympanotomy/endomeatal approach may be required.

KEYWORDS: Cochlear implant, computed tomography, facial nerve, semicircular canal

INTRODUCTION

The posterior tympanotomy with mastoidectomy approach, a classical technique for cochlear implantation, was first described by House in 1961. Alternatives that do not require the mastoidectomy of this method, which has several advantages and disadvantages, have been proposed in the literature.¹ A window is opened with a posterior tympanotomy approach to the facial recess area between the mastoid portion of the facial nerve (FN), its branch, the chorda tympani, and the fossa incudis. Posterior tympanotomy is a standard method used in cochlear implant surgery. The round window approach, which is known to be more successful in preserving hearing, has increased the popularity of posterior tympanotomy in cochlear implant surgery in recent years. In this approach, wide posterior tympanotomy is required to provide good exposure to the round window. In the posterior tympanotomy approach, in addition to the FN, its branch, the chorda tympani, is also at risk.²

Researchers have carried out many studies in this region using computed tomography (CT) to predict these risks. Hiraumi et al² attempted to determine the exact location of the chorda tympani and, thus, the FN by measuring the distance

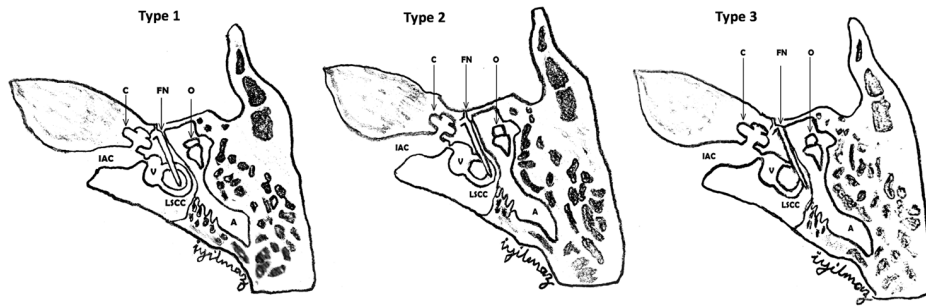


Figure 1. Schematic demonstration of the relationship between facial nerve and lateral semicircular canal. A, aditus ad antrum; C, cochlea; FN, facial nerve; IAC, internal acoustic canal; LSCC, lateral semicircular canal; O, ossicles; V, vestibule.

between the chorda tympani and the endpoint of the short arm of the incus. Similarly, Calli et al³ wanted to have information about the anatomy of the region by examining the distance between the short arm of the incus and the chorda tympani, as well as the angle between the FN and the chorda tympani. Jeon et al⁴ attempted to define the facial recess preoperatively by obtaining 3-dimensional CT images and measuring the distance and angles between the 8 points they determined. In their study examining the relationship between FN and lateral semicircular canal (LSCC) in coronal CT sections, Du et al⁵ reported that in patients undergoing mastoidectomy, the second genu of the FN that settled laterally relative to the endpoint of LSCC could be predicted. In his review of FN surgical landmarks, Wetmore⁶ noted that LSCC is a good landmark that can be used to reveal FN in the mastoid and middle ear but did not make a detailed assessment.⁶

In this study, we aimed to systematically examine the relationship between LSCC and FN in axial CT sections in order to predict the location of the FN in operations using posterior tympanotomy.

METHODS

This study was conducted at Başkent University Ankara Hospital, Adana and Konya Research and Application Centers ENT clinics, with the permission of the Baskent University Medical and Health Sciences Research Council and Ethics Committee (KA 11/17) and included 257 patients who underwent cochlear implant surgery between 2010 and 2020 and whose CT scans could be accessed.

The relationship between FN and LSCC was examined by dividing patients into 3 types based on axial sections of temporal bone CT scans with a slice thickness of 0.625 mm. If FN passed medially without contacting the LSCC dome in axial sections, it was classified as type 1; if FN passed by contacting the medial border of the LSCC dome, it was classified as type 2; and if the FN contacted the lateral border of the LSCC dome or passed more laterally, it was classified as type 3 (Figure 1). Round window or cochleostomy approaches were used for electrode insertion. The types used to define the relationship between FN and LSCC were not effective in choosing the approach. Retrospectively, demographic information and surgical findings were obtained from patient charts. Radiological and clinical data were evaluated. Computed tomography images and intraoperative pictures of the types are presented in Figures 2-4.

Imaging Technique

Temporal bone CT scans were performed with BrightSpeed 16 CT (GE Medical Systems, Milwaukee, Wis, USA). Axial views were obtained

and reformatted coronally and sagittally . Sections were aligned parallel to orbitomeatal line. Slices were 0.625 mm in thickness with 0.310 mm intervals. The window width and level were 3000 and 500 Hounsfield Units (HU), respectively.

Statistical Analysis

Statistical analysis of the data was performed using the Statistical Package for the Social Sciences 17.0 package software (SPSS Inc.; Chicago, IL, USA). The statistical relationship between the types and the requirement for the combined posterior tympanotomy/endomeatal approach was investigated using the Fisher's exact test, in which categorical variables were compared according to types.

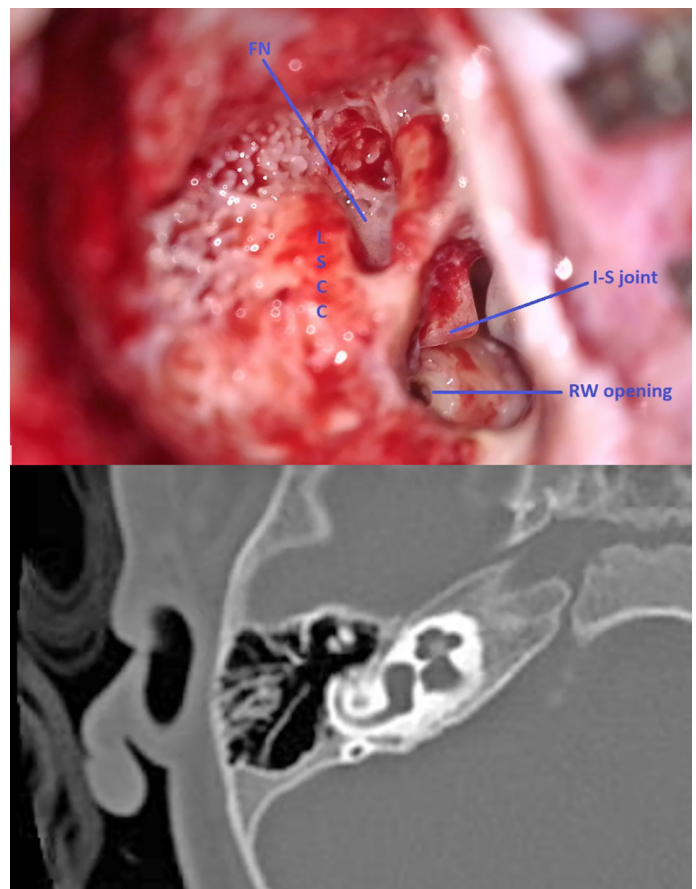


Figure 2. Intraoperative and axial section computed tomography images of type 1 patient. Note that FN passes medially without contacting the LSCC dome. FN, facial nerve; I-S, incudostapedial; LSCC, lateral semicircular canal; RW, round window.

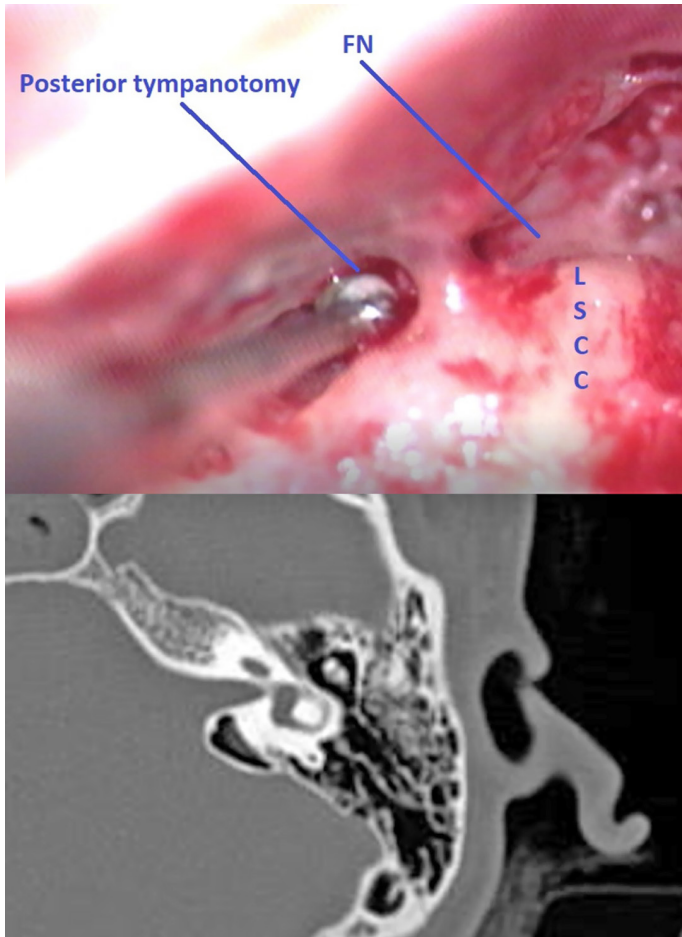


Figure 3. Intraoperative and axial section computed tomography images of type 2 patient. Note that FN passes by contacting the medial border of the LSCC dome. FN, facial nerve; LSCC, lateral semicircular canal.

RESULTS

This study included 309 ears of 257 patients, 139 males (54.1%) and 118 females (45.9%). The median age of patients at the time of surgery was 4 years (range 1-82). Two hundred five patients had 1-sided implantation, and 52 had bilateral implantation. Of the total 309 ears, 114 were left ear (36.9%) and 195 were right ear (63.1%).

Ninety-three (30.1%) of the ears were categorized as type 1, 179 (57.9%) were type 2, and 37 (12%) were type 3. The round window approach in 255 ears (82.5%) and the cochleostomy approach in 54 ears (17.5%) were used for electrode insertion. As an implant brand, 76 (24.6%) Neurelec (Sophia-Antipolis, France), 61 (19.8%) Oticon (Copenhagen, Denmark), 143 (46.3%) Cochlear (Lane Cove, Australia), and 29 (9.3%) Med-El (Innsbruck, Austria) had been implanted. It was noted that stapes reflexes were detected in 285 ears (92.2%) and not in 24 ears (7.8%). For objective electrophysiological evaluation, neural response telemetry in cochlear corporation device, auditory response telemetry in MED-el devices, and electrical evoked compound action potential in Oticon and Neurelec devices were used. It was found that Tisseel (TISSEEL [Fibrin Sealant] Kit (freeze dried) with DUPLOJECT System—2 mL, Baxter, USA) was applied to 254 ears (82.2%) and platelet-rich plasma was applied to 55 ears (17.8%) as

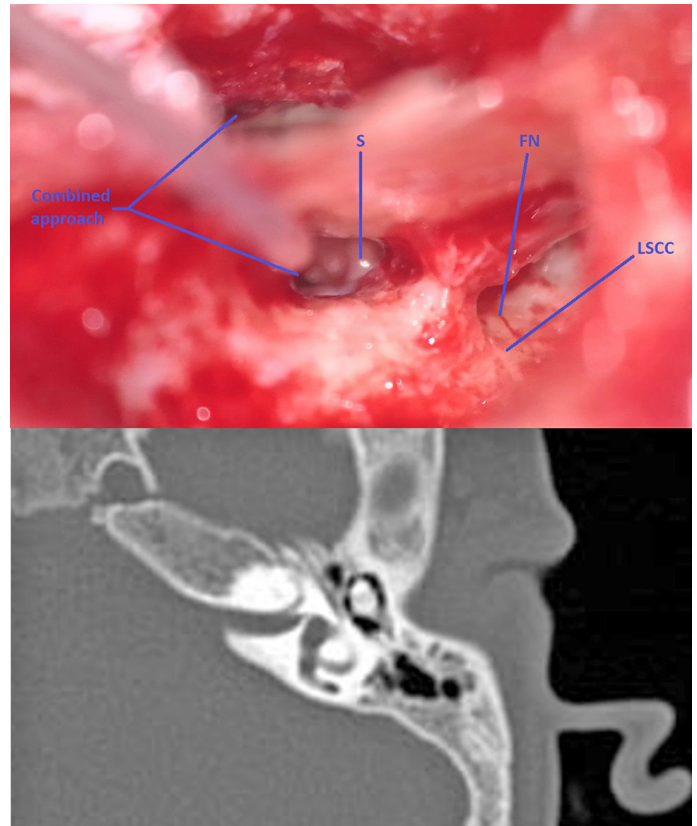


Figure 4. Intraoperative and axial section computed tomography images of type 3 patient. Combined posterior tympanotomy/endomeatal approach was required for round window exposure in this case. FN, facial nerve; LSCC, lateral semicircular canal; S, stapes.

tissue adhesive after cochleostomy or round window opening was occluded with muscle after electrode placement (Table 1).

From the surgical notes, we found that no patient had intraoperative FN damage and postoperative FN paresis or paralysis did not develop. It was found that the combined posterior tympanotomy/endomeatal approach was used in 6 ears (1.9%), of which 4 were type 3 and 2 were type 2.

A statistically significant difference was found compared to type 2 and type 3 ears in terms of their combined approach requirements ($P=.006$) (Table 2). Accordingly, the probability of requiring a combined approach in type 3 ears was significantly higher.

DISCUSSION

Preservation of the FN during posterior tympanotomy is one of the most important stages of the surgery. Computed tomography is the most important method of examination to obtain information about the position of the FN in the preoperative period. From studies using this method, Hiraumi et al² measured the distance between the chorda tympani and the long arm of the incus; they found an average of 12.6 mm (8.3-15.8 mm) in CT, 12.4 mm (8.2-16.4 mm) after dissection, and 1.1 mm between the 2 methods. These authors concluded that cone beam CT is a reliable and useful examination method for this purpose. Calli et al³ measured the same distance and found the

Table 1. Characteristics of the Study Patients

Item	Number	Percent
Sex		
Male	139	54.1
Female	118	45.9
Laterality		
Unilateral	205	79.8
Bilateral	52	20.2
Implantation side		
Left	114	36.9
Right	195	63.1
Type		
Type 1	93	30.1
Type 2	179	57.9
Type 3	37	12.0
Approach for implant insertion		
Round window	255	82.5
Type 1	74	29.0
Type 2	153	60.0
Type 3	28	11.0
Cochleostomy	54	17.5
Type 1	19	35.2
Type 2	26	48.1
Type 3	9	16.7
Brand		
Neurelec	76	24.6
Oticon	61	19.8
Cochlear	143	46.3
Med-El	29	9.3
Stapes reflex		
Yes	285	92.2
No	24	7.8
Sealing material		
Tisseel	254	82.2
Platelet-rich plasma (PRP)	55	17.8

result to be 7.78 mm (\pm 2.68), commenting that the distance tends to be greater if the angle between chorda tympani and FN (average: $23.58^\circ \pm 6.84$) is below the average. Jeon et al⁴ obtained 3-dimensional CT images and attempted to define the facial recess preoperatively by measuring the distances and angles between 8 specific points. Kim et al⁷ classified the protrusion of the FN vertical segment

Table 2. Distribution of Ears by Type

	Type 1	Type 2	Type 3	P*
Mastoid approach (n = 303)	93 (30.7%)	177 (58.4%)	33 (10.9%)	
Combined posterior tympanotomy/endomeatal approach (n = 6)	-	2 (33.3%)	4 (66.7%)	.006
Total (n = 309)	93 (30.1%)	179 (57.95)	37 (12%)	

*The statistical relationship between the types and the requirement for the combined posterior tympanotomy/endomeatal approach was investigated using the Fisher's exact test, in which categorical variables were compared according to types.

toward the mastoid antrum into 6 types in an axial temporal bone CT, suggesting that this method might facilitate the preoperative evaluation of FN.

Kim et al⁸ used CT to estimate the possibility of exposure of the first genu of the FN via the transmastoid approach and measured the bone thickness of the LSCC. Ozaki et al⁹ examined the relationship between the tympanic segment and the mastoid segment of the FN on CT in order to avoid iatrogenic FN damage during posterior tympanotomy and divided them into 3 subgroups: lateral running course (LRC), on the tympanic line course (OL), and medial running course (MRC).⁹ According to the study, 15% of ears were categorized as LRC, 30% were OL, and 55% were MRC. Compared to our study, if we accept Ozaki's LRC as type 3 (12%), OL as type 2 (57.9%), and MRC as type 1 (30.1%), we can see similar results. In our study, axial sections were preferred because they fit the surgical perspective following the path of mastoidectomy and posterior tympanotomy. We can compare this to the use of coronal sections when performing endoscopic sinus surgery in otolaryngology practice. In axial cross-sections, the most important neighborhood that the FN makes is the one with LSCC. In the surgical area, since LSCC is almost always within sight, instead of comparing the tympanic and mastoid segment of FN, unlike Ozaki et al.⁹ it was thought that positioning the FN and LSCC could be more rational. For this reason, a classification was made between 2 anatomical structures using axial CT images with a slice thickness of 0.625 mm. Thus, the relationship between these structures has been systematically revealed. In addition, instead of a complex methodology, such as distance/angle measurements, which are mostly based on the chorda tympani and the incus short arm and often require experienced radiologists, a simple and useful method that a surgeon who performs cochlear implant surgery can easily use has been proposed in this study.

Using this classification, the surgeon will be able to predict the closeness to the FN in the bone, by considering the LSCC, which is always in the field of vision, as a landmark during surgery. In our study, no problems were encountered in cases where the FN remained in the medial of the LSCC dome level, which we classified as type 1 and 2, and in 4 of the cases in which the FN remained at the LSCC dome level or lateral, which we classified as type 3, a combined approach was used, and implantation was performed without facial paralysis.

Since this investigation is a study to determine the special situation, the developmental effect of the mastoid bone has not been addressed. Investigation of the effects of development by age on the distribution of the types defined in our study is the subject of a separate study and needs large patient groups. The other limiting factor of the study is not the evaluation of the entire travel of the FN in the

facial recess, but the travel of the FN from the first genu to the proximal side of the tympanic portion.

CONCLUSION

As a result, when the posterior tympanotomy approach is used in cochlear implant surgery, knowing the relationship between FN and LSCC in thin-section axial CT, and using it during surgery is presented as a simple and useful method to prevent possible complications, such as FN damage. It is emphasized that it is necessary to consider that a combined posterior tympanotomy/endomeatal approach might be required, especially in type 3 patients.

Ethics Committee Approval: Ethical committee approval was received from Başkent University Medical and Health Sciences Research Council and Ethics Committee (KA 11/17).

Informed Consent: Informed consent was obtained from all participant.

Peer-review: Externally peer-reviewed.

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