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ORIGINAL ARTICLE

Morphometric properties of the fallopian canal: comparison of two nations with different ethnic origins

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Abstract

Purpose To determine the widths of fallopian canal segments (labyrinthine segment, geniculate ganglion, tympanic segment mastoid segment and stylomastoid foramen), in two nations with different ethnic origins, and to analyze the differences in between.

Methods We retrospectively analyzed temporal computerized tomographies of 102 individuals including 38 Turks and 64 Syrians. The widths of right and left labyrinthine (LS), tympanic (TS), mastoid (MS), geniculate ganglion (GG) and stylomastoid foramen (SF) segments of the fallopian canal were measured.

Results The narrowest segment was LS (right: 1.04 ± 0.23 mm, left: 1.03 ± 0.22 mm) and the widest segment was SF (right: 1.82 ± 0.41 mm, left: 1.85 ± 0.35 mm). From the widest to the narrowest, the widths of the FC segments were sorted as SF > GG > MS > TS > LS. The widths of the fallopian canal segments were similar between right and left sides, and between males and females ($p > 0.05$). Our results indicated that both right and left GG were significantly wider in Turks ($p < 0.001$ for both), however right LS ($p < 0.001$) and left TS ($p = 0.005$) were significantly wider in Syrian refugees. Two groups did not show any differences for the widths of other FC segments ($p > 0.05$).

Conclusions Nations of different ethnic origins may have differences concerning the widths of some segments of the fallopian canal. Further studies with a larger sample size including clinical data of the patients are needed to clarify our findings, and to determine whether these differences have any clinical implications.

Keywords Fallopian canal · Ethnic groups · Anatomy · Computed tomography

Introduction

A number of congenital, traumatic, inflammatory, and neoplastic conditions may affect the facial nerve. Accurate knowledge of the complex anatomy and course of the facial nerve and its variations are essential both for management and surgery of the facial nerve disorders.

The facial nerve passes through a long, narrow and tortuous bony canal within the temporal bone, called as fallopian canal (FC), extending from the fundus of the internal auditory meatus to the stylomastoid foramen. FC begins as the facial nerve exits the internal auditory canal at its fundus. Facial nerve has labyrinthine, tympanic and mastoid segments in FC, as well as a short segment inhabiting the geniculate ganglion. The course, length, width and angulation of normal FC have been studied in a number of radiologic and cadaveric studies [1, 3, 4, 6, 7, 9, 10]. In a CT study, around the second genu, the facial nerve was found approximately 0.5 mm posteriorly in infants and young children compared to adults. In this study, the relationship of the tympanic annulus to the facial nerve was emphasized [13]. Computed tomography (CT) has been the most frequent imaging tool for studying the morphometry of the FC since it perfectly shows the bony structures.

Since surgeons in immigration countries encounter patients of different ethnic origins, they may become more

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prone to complications during surgery. We planned this article to identify these anatomical differences and reduce possible surgical complications. In this study, we aimed to determine the widths of FC segments in Turks and Syrians with different ethnic origins, and to analyze the differences in between.

Methods

The temporal CTs of the patients admitted to Department of Otolaryngology, University of Health Sciences Adana City Training and Research Hospital between June 2019 and June 2020 were analyzed. The medical records of patients were reviewed meticulously to exclude the patients with any conditions that could affect the temporal bone anatomy. The patients with history of traumatic, oncologic, infectious or vascular disorders of temporal bone were excluded. At the end, the CTs of 102 patients (38 Turks and 64 Syrian refugees) were included in the study. There were 38 subjects (22 females and 16 males) in Group A (Turkish) and 64 subjects (32 females and 32 males) in Group B (Syrian refugees). The patients were divided into two groups as Turks (Group A) and Syrian refugees (Group B), in relation with their national identities.

A 128-detector Multi-Detector Computed Tomography (MDCT) unit (Philips Ingenuity 128, Eindhoven, The Netherlands) was used for CT imaging. The technical parameters utilized were as follows: 120 kvP, 200–400 mAs automatic tube current modulation, rotation time 0.42 s, pitch 0.6, slice thickness: 1 mm. Axial images of the temporal tomography scans were reformatted in sagittal planes. The widths of FC were measured on axial or sagittal planes imaged by temporal tomography at five different sites along the canal as follows: labyrinthine segment (LS), geniculate ganglion (GG), tympanic segment (TS), mastoid segment (MS) and stylomastoid foramen (SF). The widths of LS, GG and TS were measured at the midpoint of the segments, on the axial images. The width of MS was measured at the midpoint of the segment while SF width was measured at the most distal end of the mastoid segment, on the sagittal images. The FC widths were measured both on right and left sides.

This retrospective, single-center study was conducted in accordance with the ethical principles of the Declaration of Helsinki, after the study's protocol was approved by the Ethics Committee for Clinical Research in University of Health Sciences Adana City Training and Research Hospital (decree number: 993, meeting number: 61, date: 08 July 2020) given the study's retrospective nature, and all procedures performed were part of participants' routine care.

Statistical analysis

The study' statistical analyses were conducted using the R programme, version 3.6.0. Descriptive statistics were presented as mean ± *standard deviation* for continuous variables and as percentages and frequencies for categorical variables. Our assumption of normality was tested with Shapiro–Wilks and Kolmogorov–Smirnov tests. Since our assumption of normality was validated, a paired *t* test was used to compare the dependent variables, and a Student's *t* test was used to compare the independent variables. The study's statistical significance level was set to $p = 0.05$.

Results

The temporal bone CT scans of 102 patients were included in the study. The mean age of the patients was 32.53 ± 15.97 years (range 13–74 years), 52.94% ($n = 54$) of them were females and 47.06% ($n = 48$) of them were males. There were 38 subjects (22 females and 16 males) in Group A (Turkish) and 64 subjects (32 females and 32 males) in Group B (Syrian refugees). The mean age of the patients was 28.95 ± 16.87 years (range 13–74 years) in Group A, and 34.66 ± 15.29 years (range 14–70) in group B. Two groups were similar in the terms of gender and age ($p = 0.772$ and $p = 0.221$, respectively).

The mean widths of five segments of FC (LS, GG, TS, MS and SF) on the right and left sides of all study population, and the patients in Groups A and B are presented in Table 1. The narrowest segment was LS for both sides (right: 1.04 ± 0.23 mm, left: 1.03 ± 0.22 mm, $p = 0.811$) and the widest segment was SF (right: 1.82 ± 0.41 mm, left: 1.85 ± 0.35 mm, $p = 0.670$). From the widest to the narrowest, the widths of the FC segments were sorted as SF > GG > MS > TS > LS.

The right- and left-side measurements did not show any significant differences for any of the FC segments in whole study group, Group A or Group B ($p > 0.05$ for all comparisons, Table 1). There were no statistically significant differences for genders in whole study group, Group A or Group B for any of the segment widths of the FC (Table 2).

The width of right GG was 1.88 ± 0.24 mm in Group A, and 1.49 ± 0.31 mm in Group B ($p < 0.001$). The widths of left GG were 1.77 ± 0.17 mm and 1.49 ± 0.26 mm in Groups A and B, respectively ($p < 0.001$). On the other hand, the width of right LS was 0.78 ± 0.14 mm in Group A, and 1.04 ± 0.23 mm in Group B ($p < 0.001$). Left TS width was 1.12 ± 0.23 mm in Group A and 1.29 ± 0.19 mm in Group B ($p = 0.005$). These results indicated that both

Table 1 Comparison of right and left sides for widths of the segments of the fallopian canal

	Group A ($n=38$)			Group B ($n=64$)			Total ($n=102$)		
	Right	Left	*P*	Right	Left	*P*	Right	Left	*P*
Labyrinthine Segment	0.78 ± 0.14	0.89 ± 0.37	0.190	1.04 ± 0.23	1.03 ± 0.22	0.811	0.94 ± 0.24	0.98 ± 0.29	0.344
Geniculate Ganglion	1.88 ± 0.24	1.77 ± 0.17	0.167	1.49 ± 0.31	1.49 ± 0.26	0.880	1.64 ± 0.34	1.59 ± 0.27	0.269
Tympanic Segment	1.20 ± 0.24	1.12 ± 0.23	0.236	1.31 ± 0.23	1.29 ± 0.19	0.481	1.27 ± 0.24	1.23 ± 0.22	0.164
Mastoid Segment	1.60 ± 0.30	1.53 ± 0.31	0.233	1.44 ± 0.28	1.40 ± 0.20	0.390	1.50 ± 0.30	1.45 ± 0.25	0.165
Stylomastoid Foramen	1.79 ± 0.34	1.78 ± 0.34	0.976	1.82 ± 0.41	1.85 ± 0.35	0.670	1.81 ± 0.38	1.82 ± 0.30	0.976

The values are presented as mean ± standard deviation (mm)

Table 2 Comparison of widths of the fallopian canal segments between genders

		Group A ($n=38$)			Group B ($n=64$)			Study group ($n=102$)		
		Female	Male	*P*	Female	Male	*P*	Female	Male	*P*
Right	LS	0.76 ± 0.17	0.80 ± 0.10	0.547	1.03 ± 0.22	1.04 ± 0.24	0.927	0.92 ± 0.24	0.96 ± 0.23	0.560
	GG	1.87 ± 0.16	1.90 ± 0.34	0.839	1.55 ± 0.32	1.43 ± 0.29	0.293	1.68 ± 0.31	1.59 ± 0.38	0.335
	TS	1.21 ± 0.28	1.18 ± 0.20	0.813	1.29 ± 0.22	1.34 ± 0.24	0.609	1.26 ± 0.25	1.29 ± 0.24	0.714
	MS	1.62 ± 0.25	1.57 ± 0.37	0.727	1.41 ± 0.29	1.47 ± 0.28	0.560	1.50 ± 0.29	1.51 ± 0.31	0.928
	SF	1.81 ± 0.20	1.76 ± 0.49	0.776	1.82 ± 0.50	1.82 ± 0.31	0.980	1.82 ± 0.40	1.80 ± 0.37	0.876
Left	LS	0.78 ± 0.14	1.04 ± 0.52	0.119	1.06 ± 0.22	0.99 ± 0.22	0.368	0.95 ± 0.24	1.01 ± 0.34	0.436
	GG	1.80 ± 0.13	1.73 ± 0.21	0.341	1.51 ± 0.25	1.46 ± 0.28	0.626	1.63 ± 0.26	1.55 ± 0.28	0.303
	TS	1.14 ± 0.25	1.08 ± 0.21	0.585	1.29 ± 0.18	1.29 ± 0.21	0.986	1.23 ± 0.22	1.22 ± 0.23	0.874
	MS	1.50 ± 0.28	1.58 ± 0.36	0.604	1.43 ± 0.23	1.37 ± 0.18	0.407	1.46 ± 0.25	1.44 ± 0.26	0.782
	SF	1.76 ± 0.14	1.83 ± 0.24	0.431	1.92 ± 0.38	1.78 ± 0.32	0.260	1.79 ± 0.29	1.80 ± 0.29	0.493

Values are presented as mean ± standard deviation (mm)

LS labyrinthine segment, *GG* geniculate ganglion, *TS* Tympanic segment, *MS* mastoid segment, *SF* stylomastoid foramen

Table 3 Comparison of the width of the fallopian canal segments between Group A and Group B

		Group A ($n=38$)	Group B ($n=64$)	*P*
Right	LS	0.78 ± 0.14	1.04 ± 0.23	< 0.001
	GG	1.88 ± 0.24	1.49 ± 0.31	< 0.001
	TS	1.20 ± 0.24	1.31 ± 0.23	0.100
	MS	1.60 ± 0.30	1.44 ± 0.28	0.074
	SF	1.79 ± 0.34	1.82 ± 0.41	0.754
Left	LS	0.89 ± 0.37	1.03 ± 0.22	0.093
	GG	1.77 ± 0.17	1.49 ± 0.26	< 0.001
	TS	1.12 ± 0.23	1.29 ± 0.19	0.005
	MS	1.53 ± 0.31	1.40 ± 0.20	0.111
	SF	1.78 ± 0.18	1.85 ± 0.35	0.439

The values are presented as mean ± standard deviation (mm)

LS labyrinthine segment, *GG* geniculate ganglion, *TS* Tympanic segment, MS mastoid segment, *SF* stylomastoid foramen

right and left GG were significantly wider in Group A ($p < 0.001$ for both); however, right LS ($p < 0.001$) and left TS ($p = 0.005$) were significantly wider in Group B. Two groups did not show any differences for the widths of other FC segments (Table 3).

The facial nerve segments (Fig. 1A–D) and the distribution of their diameters (Figs. 2, 3) are shown below. The intratemporal facial nerve and its complex course in the middle ear are demonstrated by our own drawing (Fig. 4).

Discussion

In this CT study, we investigated the FC widths among patients representing two different nationalities with distinct ethnic origins. We found significant differences between these two groups vis-à-vis the widths of some FC segments, particularly the GG segment.

The FC's width-related anatomical characteristics are clinically and surgically significant. CT has been employed widely to study the FC's anatomy and variations [1, 2, 5–7, 9–12]. Various authors have compared CT and cadaver measurements of the FC's anatomy [11, 12], while some other authors have compared CT and anatomical measurements across various samples [6]. A study in China revealed that some aspects of the mastoid segment of the

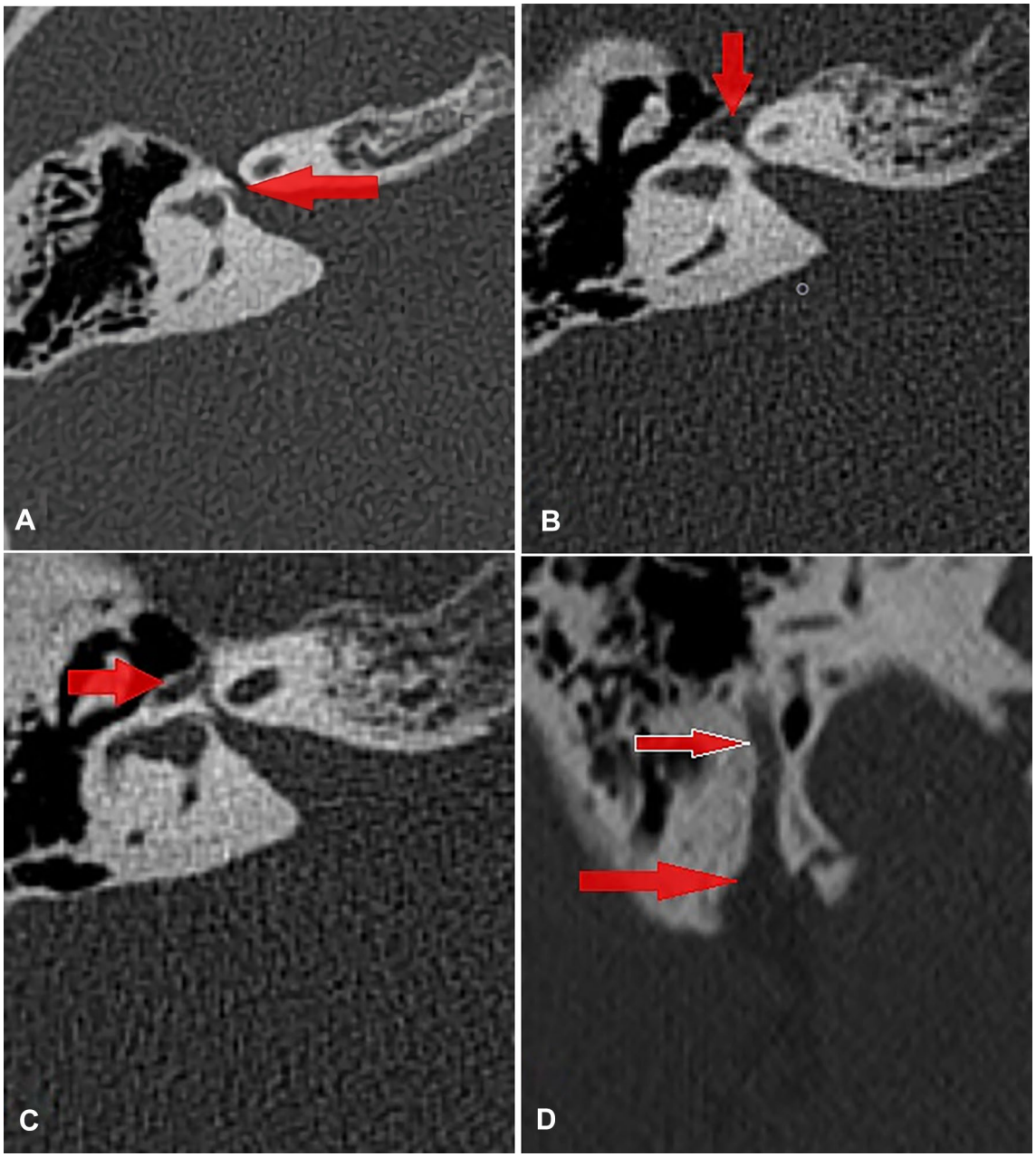

Fig. 1 **A**–**D** CT images of the right temporal bone scan **A** Axial CT section: Labyrinthine segment, by a red arrow. **B** Axial CT section: geniculate ganglion, by a red arrow. **C** Axial CT section tympanic segment, by red arrow. **D** Coronal CT section: mastoid segment proximal by red–white arrows, and stylomastoid segments by red arrows

facial nerve are not compatible with those described in the western literature. It shows that ethnic differences lead to the existence of various mastoid morphologies. The surgeon's lack of anatomical knowledge for intraoperative injuries and facial nerve complex topography are the main causes. The experience of the surgeon is very important to reduce this risk [8].Understanding the anatomical relationships between structures can play a decisive role in the otologic surgical approach. Evidently, CT measurements align with anatomical studies, and CT may be used to study the FC before surgery or to inform anatomical considerations.

The FC's anatomy is also important in understanding the pathophysiology of Bell's palsy. Indeed, the only documented findings that explain the etiology of Bell's palsy are inflammation and oedema of the facial nerve in the narrow FC, resulting in nerve entrapment [2, 5, 6], though the cause of this inflammation has been debated. Moreover, information on the FC's racial anatomical differences

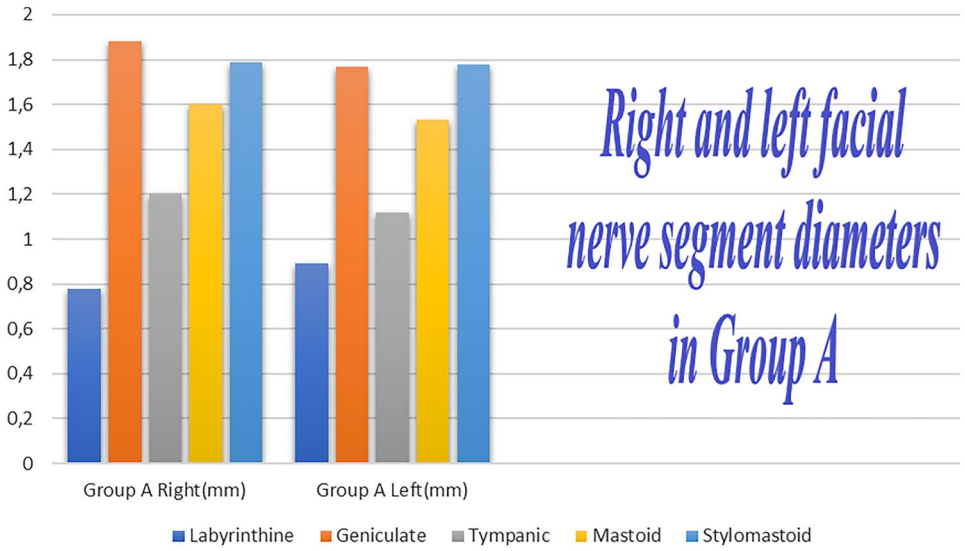

Fig. 2 Facial nerve segment diameters in Turks

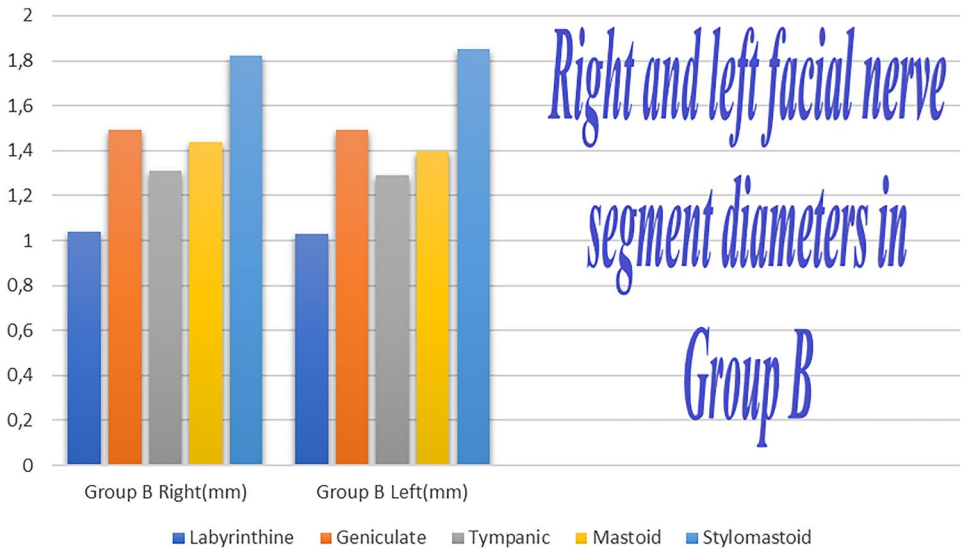

Fig. 3 Facial nerve segment diameters in Syrians

is scarce, and to our knowledge, no studies have yet investigated national differences among Caucasians. Turks and Syrians are both Caucasian; however, their ethnic origins differ. Recently, many Syrian refugees have migrated to Turkey, particularly the country's southern region. The unusual anatomical differences created by this migration wave may push clinicians and surgeons to undesirable complications.

Komori et al. [6] reported that the width of FC expanded from the meatal foramen towards the geniculate fossa, and then gradually narrowed towards the level of stapes and expanded again towards the stylomastoid foramen. Studies indicated that the width of the FC is narrower at the middle part of meatal foramen and LS [2, 5, 6]. In the present CT study, from the widest to the narrowest, the mean widths of the FC segments were sorted as SF > GG > MS > TS > LS (Table 1).

Ossification on the FC's LS occurs before the 15th week of gestation; however, ossification of the TS and MS is delayed until after the 20th week of gestation, completing at approximately the 28th week of gestation. Although the majority of development is completed during the prenatal period, 17% of the canal's development continues after birth [1, 3, 6, 10]. Beger et al. [1] investigated the FC's morphometric properties among children, demonstrating that although the widths of the MS, LS and meatal foramen do not change with age, the width of the TS increases. They also reported no differences in FC widths between male and female patients or between the right and left temporal bones [1]. Komori et al. [6] measured FC widths at certain points among healthy adults, reporting that FC segments' widths were similar on the left and right temporal bones. Our findings align with the findings of these previous studies since we observed no differences in FC segments' widths

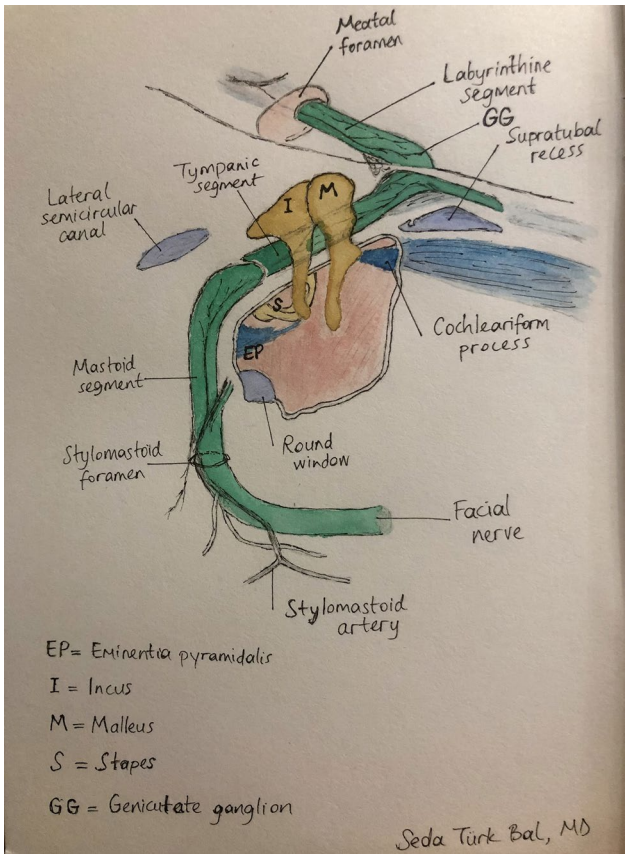

Fig. 4 Intratemporal facial nerve and middle ear

between the right and left temporal bones or between male and female patients.

Racial FC differences have not been extensively studied. The authors of a cadaveric study measured the FC segments' widths among Caucasian and Japanese subjects, reporting that the FC was slightly wider among Caucasians; however, the shape and the direction of the FC segments were similar between the two groups—though the authors did not conduct any statistical analysis [6]. To our knowledge, our study is the first to have investigated FC segments' widths among patients representing two nations with distinct ethnic origins. Our study found both the right and left GG to be significantly wider among Turks ($p < 0.001$ for both) while the right LS ($p < 0.001$) and left TS ($p = 0.005$) were significantly wider among Syrian refugees. Our findings suggest that FC widths may differ by ethnicity.

Our study faced some limitations. First, it was conducted at a single institution using a retrospective design, and its cohort size was relatively small. Second, we did not study the facial nerve itself while examining the FC; therefore, we did not investigate the space between the canal and the nerve. The widths of five different sites of the fallopian canal are measured at their midpoints, while it is not an accurate method of localization without giving careful consideration to reliable landmarks. It is important to determine the specific points for measuring segments of the canal and take into account the significance of points. In practical views, it is important to determine the most valuable points of the fallopian canal that helps surgeons avoid damaging the surrounding vulnerable structures.

Conclusion

This study's results offer evidence that FC widths are similar on the right and left sides, as well as between male and female patients. Nationalities of distinct ethnic origins may have differing widths for some FC segments. Further studies with a larger sample size—including patients' clinical data—are needed to clarify our findings and determine whether these differences have any clinical implications.

Author contributions KKB protocol development, data collection and management, data analysis, manuscript writing and editing. SA protocol development, data collection and management, data analysis, manuscript writing and editing. STB manuscript editing, design of figures and handmade anatomical drawing. TO protocol development, data management, data analysis, manuscript editing. OG protocol development, data management, data analysis, manuscript editing. OD protocol development, data collection and management, data analysis, manuscript writing and editing.

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Data availability The authors are keeping all data, and may present them if needed.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval Ethics Committee for Clinical Research in University of Health Sciences Adana City Training and Research Hospital approved the study protocol (decree number: 993, meeting number: 61, date: 08/07/2020) in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

Consent to participate The study has a retrospective design, and patients' informed consents are not available. The images used in the study do not contain any data on the identity of the participants.

Consent for publication The study has a retrospective design, and patients' consents for publication are not available. The images used in the study do not contain any data on the identity of the participants.

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