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Original Article

Morphometric study of Intratemporal course of facial nerve in relation to pneumatization of temporal bone—An original study

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ABSTRACT

Introduction: Facial nerve (C.N VII) is the nerve of facial expression and communication. The intratemporal part of this nerve comprising tympanic and mastoid segments, is very vulnerable to injury during ear surgeries. Hence to safely navigate around this part of the nerve one has to be very familiar with 3D anatomy of the temporal bone and crucial landmarks present in relation to the nerve. Aim of this study is to know the exact morphometry of Intratemporal part of the facial nerve in relation to Pneumatization of temporal bone.

Material and methods: The present study was carried out on 54 cadaveric temporal bones obtained from the department of anatomy, Santosh Medical College, Santosh University, Delhi-NCR. With the pneumatization determined by computerized tomography (CT), the dissection was performed by standard techniques of '*canal wall up*' mastoidectomy and '*canal wall down*' mastoidectomy. Temporal bones have been classified into 3 groups: Group I-Well Pneumatised bones, Group II- Mixed type of Pneumatised bones and Group III- Sclerosed bones. The mean, standard deviation (S.D), maximum and minimum values were calculated in all the groups for the lengths of the facial nerve.

Results: The total length of the intratemporal part of facial nerve ranged between 19.71–30.13 mm for group I, 21.77–27.27 mm in group II and 16.21–25.19 mm in group III respectively.

Discussion: The distal segment of nerve is most commonly injured during otologic surgeries. Incus pointer can be considered as a landmark to identify the facial nerve. Accordingly the tympano mastoid part of the facial nerve can be divided into proximal, distal and stylomastoid foramen segments. Radiological evaluations such as Computed Tomographic (CT) imaging techniques and MRI techniques like FIESTA (Fast Imaging Employing Steady-state Acquisition) have become popular in identifying these segments. The morphometric values of facial nerve provided in the present study can help in assessment during procedures, like end to end anastamosis and cable nerve graft repairs in iatrogenic injuries.

1. Introduction

Facial nerve(VIIN) is the nerve of facial expression and communication hence also called *'Queen of the face'*. It contains motor, sensory and secretory components. It has 10000 fibres of which 7000 are motor and 3000 are somatosensory and secreto-motor.[1] Facial nerve arises from the pontomedullary junction and courses through cerebellopontine angle (CPA), internal acoustic meatus and tympanomastoid part of temporal bone(intratemporal course) to exit from the cranial cavity through stylomastoid foramen.[2] In the temporal bone it gives rise to greater petrosal nerve, nerve to stapedius and chorda tympani nerve. After exit from cranium, it courses peripherally to divide into five terminal branches namely temporal, zygomatic, buccal, marginal mandibular and cervical after giving off posterior auricular nerve, nerve to stylohyoid, and nerve to digastric.[3]

This nerve is unique in the sense that it exhibits a number of variations and also has the distinction of having the longest course

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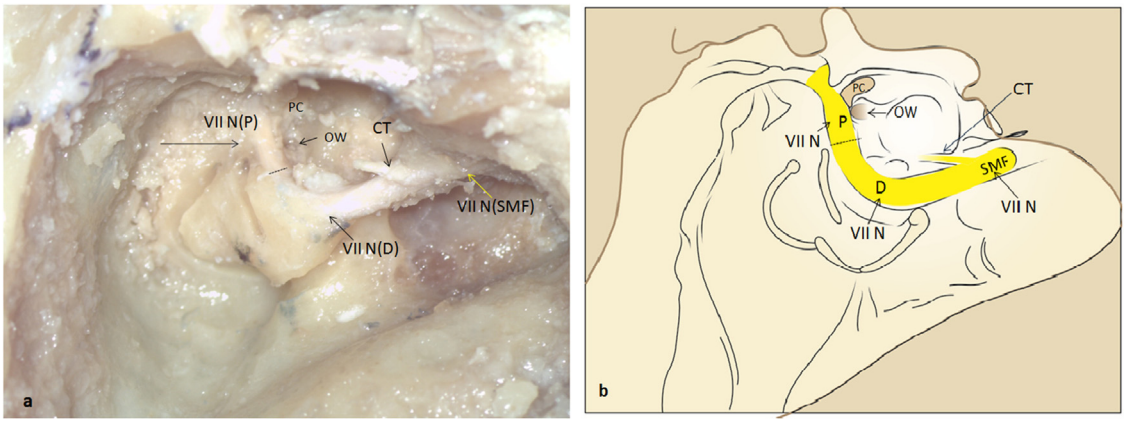

Fig. 1. a. Right sided temporal bone with intratemporal part of facial nerve exposed by microdissection, b. Illustrative figure exhibiting the same.VII N(P)-Proximal segment, VII N(D)- vertical segment, VII N (SMF)- stylomastoid foramen segment, CT- chorda tympani nerve, PC-Processus cochleariformis, OW-oval window.

in a bony canal (fallopian canal).[1] The present study emphasizes on the intratemporal part of the nerve (i.e., proximal, distal and stylomastoid foramen segments) (Fig. 1). According to literature this part of the nerve is prone to iatrogenic injuries while performing otologic surgeries for various diseases.[4] There are several studies defining tympano mastoid segment of the facial nerve but very few have correlated these values to the pneumatization, since this can provide otologists with a clear understanding and caution before performing the surgery. The aim of the present study is to give a comprehensive morphometry of this part of the facial nerve in correlation with pneumatization of the temporal bone.

2. Material and methods

The present study has been carried out on 54 temporal bones obtained from the department of anatomy, Santosh Medical College, Santosh University, Delhi-NCR from 2015 to 2017. Institutional ethical clearance has been obtained with reference letter no. SU/2016/431(2). All temporal bones were subjected to computerised tomography (CT) scanning(1 mm cut sections) to determine the type of pneumatization. With the evidence of CT scans for pneumatization dissection was performed by standard techniques of *'canal wall up'* mastoidectomy and *'canal wall down'* mastoidectomy.[5] The dissection was done with the help of Leica M320 dissection microscope with inbuilt camera and serial photographs were taken. The lengths of the facial nerve were obtained by analyzing these photographs with open software Fiji[6] by standardizing the scale to mm (millimeter). For utmost accuracy, the mastoid segment was further divided into two parts, distal segment and stylomastoid foramen segment.

The following parameters were considered (Fig1):

Total length of the facial nerve: From Processus cochleariformis to Stylomastoid foramen.

Proximal Segment: From Processus cochleariformis to Incus pointer(tympanic/horizontal part).

Distal segment: From Incus pointer to origin of chorda tympani nerve(mastoid/vertical part).

Stylomastoid foramen segment: From origin of chorda tympani to stylomastoid foramen(exit part).

2.1. Statistical Analysis

The mean, standard deviation (S.D), maximum and minimum values were calculated in all the groups for the lengths of the facial nerve. The three groups have been analysed statistically by one-way ANOVA using SPSS version 22.0.0(2014).

3. Results

Intratemporal part of facial nerve is divided into three subparts with the above defined landmarks (vide supra). The measurements given in the present study have been classified into three groups based on the type of pneumatization determined by radiology and gross dissection as below:

Group I where the temporal bones were found to have well pneumatised air cells (high cellularity), Group II where the temporal bones were found to have mixed type of pneumatised air cells (mixed cellularity), Group III where the temporal bones were found to have sclerosed type of bone with no air cells (no cellularity).

The results have been tabulated accordingly and are given in Tables 1–3

The total length of the facial nerve ranged between 19.77–30.13 mm, where as this length has been slightly lower in the group II and III i.e., 21.77–27.27 mm and 16.21–25.19 mm respectively.

The proximal segment of facial nerve in group I has a mean length of 8.47 ± 1.17 mm;9.40 ± 0.77 mm in group II and 8.27 ± 1.21 mm in group III.

The distal segment of the nerve in group I has a mean length of 10.58 ± 1.68 mm, 11.05 ± 1.91 mm in group II and 8.57 ± 2.68 mm in group III

The stylomastoid foramen segment in group I has mean length of 4.39 ± 0.76 mm, group II 4.74 ± 2.85 and 3.60 ± 0.71 mm in group III.

The results of ANOVA are given in Table 4

4. Discussion

The tympanic part of the facial nerve extends from geniculate ganglion to the 2nd genu(external genu). It passes along the longitudinal axis of the petrous bone. Here it lies superior and lateral to the oval window and anteromedial to lateral semicircular canal. The mastoid segment extends from the 2nd genu to stylomastoid foramen. This segment lies lateral to PSCC (Posterior Semicircular canal) in the posterior wall of the tympanic cavity. It courses inferiorly through facial canal to emerge out of cranial cavity through stylomastoid foramen. The usual anatomical landmarks used to identify the facial nerve during surgery to avoid iatrogenic injuries are: (a) processus cochleariformis, oval window, and stapes were used for proximal segment of the nerve. (b) Lateral semicircular canal, posterior semicircular canal, and digastric ridge were used for the distal segment of the nerve.[7] As noted by Wetmore SJ, chorda tympani is also frequently used in the identification of the facial nerve in the mastoid region.[8] In present

Table 1
Facial nerve measurements in Group I (well pneumatised).

Parameters	Mean	Standard Deviation	Minimum	Maximum
Proximal segment (mm)	8.47	1.17	6.29	10.89
Distal segment (mm)	10.58	1.68	7.28	15.70
Stylomastoid foramen segment (mm)	4.39	0.76	2.91	5.80
Total length(mm)	23.44	2.50	19.71	30.13

Table 2
Facial nerve measurements in Group II (mixed).

Parameters	Mean	Standard Deviation	Minimum	Maximum
Proximal segment (mm)	9.40	0.77	8.37	10.64
Distal segment (mm)	11.05	1.91	7.75	15.31
Stylomastoid foramen part(mm)	4.74	2.85	3.08	12.65
Total length (mm)	23.64	1.70	21.77	27.27

Table 3
Facial nerve measurements in Group III (sclerosed).

Parameters	Mean	Standard Deviation	Minimum	Maximum
Proximal segment (mm)	8.27	1.21	6.11	10.10
Distal segment (mm)	8.57	2.68	1.80	11.93
Stylomastoid foramen segment (mm)	3.60	0.71	2.58	4.75
Total length (mm)	21.04	2.44	16.21	25.19

Table 4
Results of ANOVA between the three groups.

Parameter	Group I	Group II	Group III	P value
Proximal segment (mm)	8.47 ± 1.17	9.40 ± 0.77	8.27 ± 1.21	0.002
Distal segment(mm)	10.58 ± 1.68	11.05 ± 1.91	8.57 ± 2.68	0.000
Stylomastoid foramen segment(mm)	4.39 ± 0.76	4.74 ± 2.85	3.60 ± 0.71	0.002
Total length(mm)	23.44 ± 2.50	23.64 ± 1.70	21.04 ± 2.44	0.000

study the incus pointer(the pointed edge of short process of incus) has been considered as a landmark to identify the facial nerve, the same can be used during ear surgeries as an essential landmark (Fig. 2). Proximal segment of the nerve is present anteromedial to incus pointer (IP), Distal segment of the nerve is present inferior to IP, and below the origin of Chorda tympani nerve this distal segment is considered as Stylomastoid foramen segment (Fig. 3).

A mean length of 10.97 ± 1.29 mm for the tympanic segment of the facial nerve was recorded in the study done by Nikolaidis et al[9] which is close to the values i.e., 9.40 ± 0.77 mm, obtained in the present study. The lengths of tympanic segment and mastoid segment(Distal segment + Stylomastoid foramen segment) in the study done by Maru et al[10] are 10.25 ± 0.75 mm and 13.78 ± 1.22 mm respectively (Table 5). These results are similar to the present study. They concluded in favor of the above landmarks mentioned. They added annulus tympanicum and chorda tympani as well.In the study of Kharat et al[11] the mean length of tympanic segment was 9.28 ± 1.13 mm which is similar to length 9.40 ± 0.77 mm in the present study whereas for the mastoid segment it was 13.7 ± 1.45 mm compared to the length of

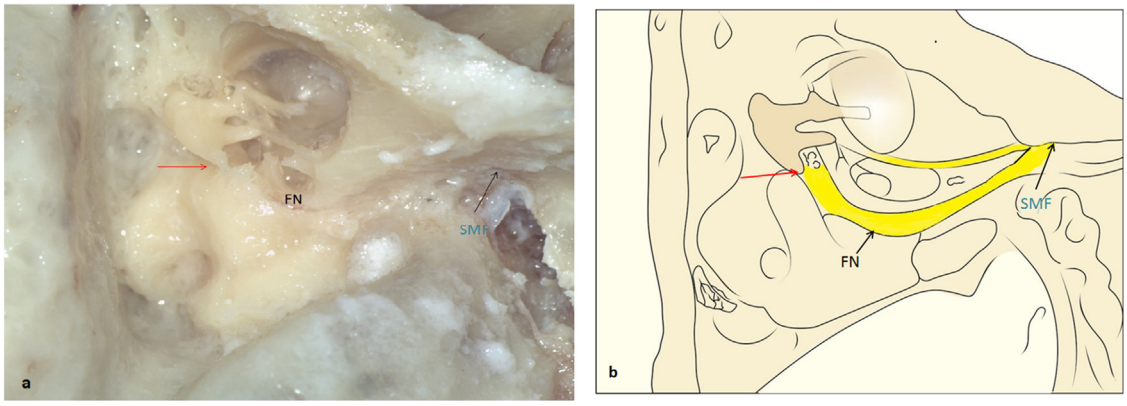

Fig. 2. a Right sided temporal bone showing incus pointer(Red arrow), b. Illustrative figure exhibiting the same. FN-Facial Nerve, SMF-Stylomastoid foramen.

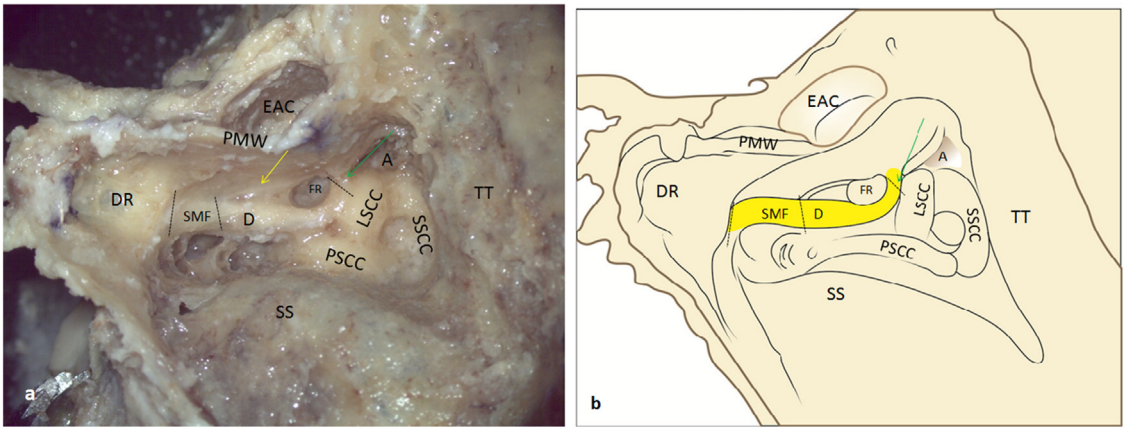

Fig. 3. a Left sided temporal bone with facial nerve exposed along with Incus pointer(green arrow), chorda tympani(yellow arrow), Distal segment(D), stylomastoid foramen segment(SMF) b. Illustrative figure exhibiting the same. EAC- external auditory canal, PMW-Posterior meatal wall, DR-digastric ridge, SS-Sigmoid sinus, TT-tegmen tympani, A-Antrum, LSCC-Lateral semicircular canal, PSCC-Posterior Semicircular canal, SSCC-Superior semicircular canal.

Table 5
Comparison of lengths of facial nerve between different studies and present study.

Parameters	Proctor & Nager[1]	Boemo et al[4]	Nikolaidas et al[9]	Nicoleta maru et al[10]	Kharat et al[11]	Rulon & Hallberg[13]	Kudo & Nori[15]	Yadav S.P.S et al[16]	Present Study
Tympanic Segment (mm)	10–12	NA	10.97 ± 1.29	10.25 ± 0.75	9.28 ± 1.13	9.5	12.135	11.1 ± 0.8	10.58 ± 1.68
Mastoid Segment(mm)	NA	13.34 ± 1.43	NA	13.78 ± 1.12	13.7 ± 1.45	11.5	13.75	15.4 ± 2.14	12.86 ± 1.93

12.86 ± 1.93 mm in the present study. In Şentürk et al[12] the mastoid segment was 12.28 ± 1.90 mm in length. A detailed comparison of lengths of tympanic and mastoid segments of the facial nerve has been given in Table 5.

From the results we can see that one way ANOVA has given a p-value <0.05, indicating a clear relationship between the variations of facial nerve morphology and the pneumatization of temporal bone i.e., lengths of the nerve have been significantly higher in the bones with pneumatization, almost by 2 mm for the distal segment when compared to sclerosed bones. The sclerosed bones also exhibited an overall decrease in the total length of the nerve.

Anatomical variations in temporal bones have been highlighted in previous studies,[13,14] due to variations in the morphology, which causes difficulties in performing ear surgeries leading to complications during surgery. Identification of VII nerve is difficult in sclerosed bones compared to the well pneumatised bone due to its altered anatomy. Thorough radiological evaluation is advised in any or all otological diseases since it provides not only disease extension, but also relation to surrounding structures.

4.1. Clinical Application

The Iatrogenic facial nerve injury is most common during otologic surgeries. Distal segment of the facial nerve is damaged especially in any of the transmastoid approaches.[4] Application of aforesaid landmarks is very essential to avoid the injury especially in the diseased and sclerosed mastoids. Any soft tissue present around the mentioned landmarks should be considered as facial nerve and its course has to be delineated to reduce the risks. In case of unfortunate injuries, the nerve should be repaired immediately. However, the methods of repair depend on the duration of injury, since the nerve doesn't regenerate as the time prolongs. In these conditions static methods, such as Gold-weight implant etc., are advised to improve the functional quality of life.

5. Conclusion

The incus pointer can be a good anatomical landmark for the identification of facial nerve during ear surgeries. The study implies a consistent relationship between the lengths of tympanic, mastoid and stylomastoid foramen segments of the facial nerve with pneumatization of the temporal bone. Preoperative radiological assessment is recommended to know the disease, its extension and relationship to surrounding structures along with course of facial nerve. Nowadays recent advances in radiology can help surgeons to reconstruct the facial nerve course, providing better knowledge of the morphological features. The morphometric values of facial nerve provided in the present study can help in assessment during procedures, like end to end anastamosis and cable nerve graft repairs in iatrogenic injuries.

Conflict of interest

No conflict of interest.

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