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Original Research Article

SURGICAL ANATOMY AND LAND MARKS OF TYMPANOMASTOID SEGMENT OF FACIAL NERVE USING MORPHOMETRY AS A MEASUREMENT TECHNIQUE: CADAVERIC TEMPORAL BONE DISSECTION STUDY

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ABSTRACT

Introduction: Facial nerve is unique in terms of a long and tortuous course in a bony canal within the temporal bone. The intricate course of the nerve is of vital concern to all otologic surgeons as maximum otological surgeries involve tympanomastoid segment of the nerve. While removing the disease, surgeons need to pay attention to the adjacent reliable landmarks, to ensure complete removal of disease while avoiding injury to the facial nerve.

Aim: To study the tympanomastoid course of facial nerve and to determine its effective surgical landmarks using morphometry

Material and methods: The present study was conducted in the temporal bone dissection laboratory in the Department of Otorhinolaryngology, AFMC, Pune on 20 temporal bones (ten left and ten right) harvested from cadavers from the Department of Anatomy, AFMC Pune. The temporal bones were dissected under Karl Zeiss Operating microscope with an inbuilt camera. Images were captured and morphometric analysis of the recorded images was performed with image analysis software.

Observations and Results: Standard surgical approach was commenced with cortical mastoidectomy followed by facial recess approach. The distance between the facial and chorda tympani nerve was measured. Subsequently posterior canal wall was removed to study the relationship of Lateral semicircular canal and ossicles with the facial nerve. Normal surgical landmarks are often distorted in the diseased mastoid. Therefore, the surgeon should use as many of the available anatomical landmarks which act as a frame of reference for the facial nerve location.

Conclusion: Cochleariform process, distance of tympanic segment of facial nerve from the dome of lateral semicircular canal, short process of incus and pyramid were found to be constant landmarks. It is extremely important that surgeons are well versed with the surgical anatomy of facial nerve and various landmarks for its identification.

KEY WORDS: Facial nerve, Chorda tympani, Cochleariform process.

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INTRODUCTION

Facial nerve has a long and tortuous course in a bony canal within the temporal bone. It is of vital concern to otologic surgeons as it traverses their surgical field frequently. The tympanomastoid segment is of great importance as maximum otological surgeries involve this portion of the temporal bone. Hence surgical anatomy of facial nerve and various landmarks for its identification is vital.

Otologist having inadequate familiarity with temporal bone can take away patients smile by iatrogenic insult to facial nerve. Intra temporal facial nerve bony canal course is three dimensional, complex and fascinating to anatomists and otorhinolaryngologist. So its thorough knowledge including its variations is of immense importance and critical to avoid iatrogenic disaster. While removing the disease, attention to the adjacent structures should be given which serve as reliable landmarks, to ensure complete removal of disease while avoiding injury to the facial nerve.

There is no substitute of thorough knowledge which is gained by temporal bone dissection to study its curves and deficiencies of bony facial canal and its variations which every human carries because of its evolution.

The temporal bone consists of mastoid process, squamous part, tympanic part and petrous part. Styloid process is closely related to it but it is not considered its part [1]. Galen first described facial nerve (130-200B.C) consisting of 10,000 sensory, motor and parasympathetic fibres [2].

Intra operative injury to facial nerve is not unknown with data ranging from 0.6-3.6% which increases up to 10% in revision surgeries [3].

This study was done on wet temporal bone with an aim to know the intra temporal course of facial nerve along with its deviations from its known path to understand its surgical anatomy and to help surgeons during ear surgeries to avoid facial disfigurement and emotional distress to patients by iatrogenic injury to the nerve.

Aim: To study the tympanomastoid course of facial nerve and to determine its effective surgical landmarks using morphometry

OBJECTIVES

To use morphometry to measure the following segments:

· Length of tympanic & mastoid segments

· relationship from processus cochleariformis, oval window, stapes head, pyramid

· Depth of facial nerve at second genu, stylomastoid foramen

· To compare the results with previous studies

MATERIALS AND METHODS

The study was conducted at a tertiary care center for three months on 20 adult cadaveric wet temporal bones obtained from Dept of Anatomy.

After thorough cleaning of temporal bone specimen, it was mounted on House temporal bone holder. Following landmarks were identified: Mac Ewens triangle, Spine of Henle and supra mastoid crest.

Facial nerve canal was exposed in toto in its entire tympanomastoid segment by standard transmastoid surgical approach; bony canal was thinned down to completely take out facial nerve from its abode.

The facial nerve was dissected under Karl Ziess operating microscope with an inbuilt camera. Tympanomastoid segments were measured using divider and measuring probe and read against millimeter probe. The length of tympanic and mastoid segments, relationship from processes cochleaformis, oval window, depth of facial nerve at second genu and stylomastoid foramen were measured. Dehiscence of fallopian canals, its variations and abnormality if any were also looked for.

Images were captured at each stage to define the relationship of various landmarks with the facial nerve. Morphometric analysis of the images was performed with image analysis software .

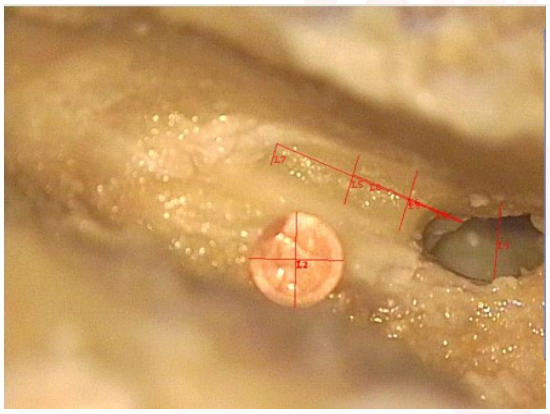
OBSERVATION AND RESULTS

The following results were obtained after intricate and delicate dissection of 11 (55%) right sided and 9 (45%) left sided wet temporal bones. The mean length of tympanic segment of facial nerve was 11.38+/-1.95mm with variation

ranging from 8.5 mm to 13.4mm**.(Table 1)** The mean length of mastoid segment of facial nerve was 13.98+/-2.32 mm with variation ranging from 11.5 mm to 17.1mm. **(Table 2)** The mean angle at second genu was 113.6+/- 13.83 with variation ranging from 95 degree to 133 degree. **(Table 3)** The mean distance between chorda tympani and facial nerve was 6.56 mm from its origin till it reaches stapes head area. **(Table 4)**

The mean distance between chorda Tympani and facial Nerve at the region of sentinel cell where opening for posterior tympanotomy is made was 2.82 +/- 0.22 mm. **(Table 5)(Fig 1)** The mean distance between Pyramid to Facial Nerve was 1.38+/- 0.23mm. **(Table 6)(Fig 2)** The mean distance between Cochleariform process to Facial Nerve was 2.47mm+/-0.10. **(Table 7)** The mean distance between stapes head to Facial Nerve was 2.19mm+/-0.26. **(Table 8)(Fig 2)** The mean distance between dome of Lateral semicircular canal to Facial Nerve was 1. 30mm+/-0.17. **(Table 9)**

Fig. 1:



L1 and L2 = Grid diameters

L3= Distance between Chorda Tympani nerve and facial nerve at a distance of 1.77

mm from Stapes head (**L4**)posteriorly =2.09 mm.

L5= Distance between Chorda Tympani nerve and facial nerve at a distance 3.7 mm

from Stapes head (**L6**)posteriorly =1.72 mm

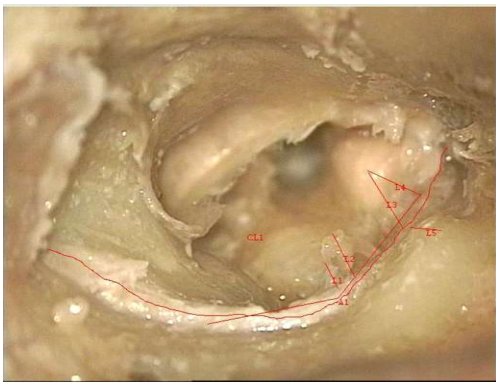
L7= Distance between Chorda Tympani nerve and facial nerve near the origin of

Chorda Tympani =0.76 mm

L8= Distance between stapes head to origin of Chorda Tympani (length of the opening without sacrificing Chorda Tympani nerve = 6.22 mm

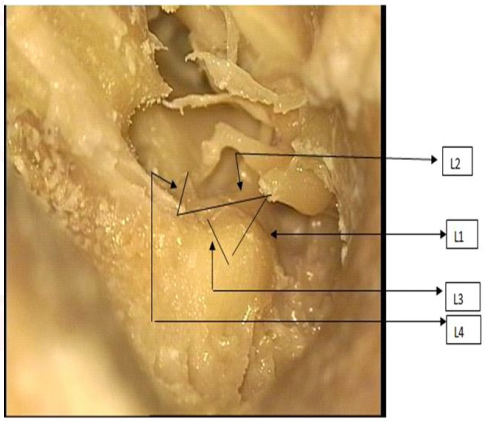
L9= Distance between Chorda Tympani and Facial Nerve at the region of sentinel cell where opening for posterior tympanotomy is made = 2.69 mm

Fig. 2:



L1= Distance between Pyramid to Facial Nerve = 1.22 mm
L2= Distance between Stapes head to Facial Nerve = 2.07 mm
L3= Distance between Cochleariform Process to second genu of Facial Nerve =2.79 mm
L4=Straight distance between Cochleariform Process to Facial Nerve = 2.43 mm
L5= Distance between Dome of Lateral semicircular canal to Facial Nerve = 1.26 mm
CL1= Curved length of Tympanomastoid segment of Facial Nerve = 23 mm
A1 = Second Genu Angle = 131 degrees

Fig. 3:

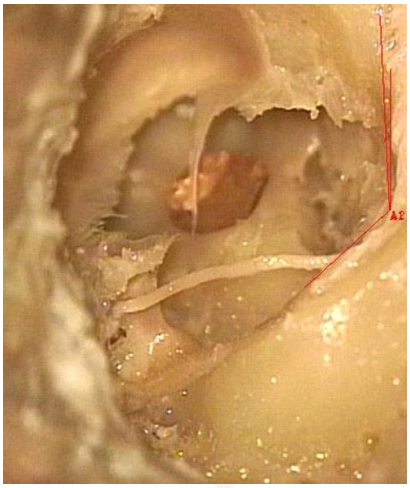


L1= Distance between tip short process of incus to dome of Lateral semicircular canal =2.06 mm
L2= Distance between tip short process of incus to second genu of Facial Nerve = 2.41 mm
L3= Distance between dome of Lateral semicircular canal to Facial Nerve 2nd Genu =2.79mm
L4= Distance between tip of pyramid and Facial Nerve = 1.13mm

Fig. 4:

Length of the vertical or mastoid segment of Facial Nerve = 13.4 mm

Fig. 5:



Angle at the 2nd genu of facial nerve:
A1=131 degrees **A2** =133 degrees

Table 1: Showing the Length of Tympanic Segment (mm).

Length of Tympanic Segment (mm)	No. of Temporal Bones	%
8.5	3	15
10.5	7	35
11.7	6	30
12.8	2	10
13.4	2	10
Total	20	100
Mean length	11.38	
SD	1.95	

Table 2: Showing the Length of Mastoid Segment (mm).

Length of Mastoid Segment(mm)	No. of Temporal Bones	%
11.5	2	10
12.3	5	25
13.4	5	25
15.6	6	30
17.1	2	10
Total	20	100
Mean length	13.98mm	
SD	2.32	

Table 3: Showing the Angle at Second genu (mm).

Angle at Second genu (degree)	No. of Temporal Bones	%
95	2	10
100	3	15
105	3	15
110	4	20
115	1	5
120	2	10
131	4	20
133	2	10
Mean	113.6 (degree)	
SD	13.83	

Table 4: Distance between stapes head to origin of Chorda Tympani(mm).

Distance between stapes head to origin of Chorda Tympani(mm)	No. of temporal Bones (%)
6	2(10%)
6.2	8(40%)
6.5	5(25%)
6.9	3(15%)
7.2	2(10%)
Mean	6.56mm
SD	0.49

Table 5: Distance between chorda Tympani and facial Nerve at the region of sentinel cell (mm)

Distance between chorda Tympani and facial Nerve at the region of sentinel cell (mm)	No. of temporal Bones (%)
2.55	2(10%)
2.69	9(45%)
2.77	4(20%)
2.85	3(15%)
3.15	2(10%)
Mean	2.82mm
SD	0.22

Table 6: Distance between Pyramid to Facial Nerve (mm).

Distance between Pyramid to Facial Nerve(mm)	No.of Temporal Bones (%)
1.1	2 (10%)
1.22	9 (45%)
1.4	4 (20%)
1.5	3 (15%)
1.7	2 (10%)
Mean	1.38mm
SD	0.23

Table 7: Distance between cochleariform process to Facial Nerve(mm).

Distance between cochleariform process to Facial Nerve(mm)	No.of Temporal Bones (%)
2.35	2 (10%)
2.43	11 (45%)
2.5	4 (20%)
2.6	3 (15%)
Mean	2.47mm
SD	0.1

Table 8: Distance between Stapes head to Facial Nerve(mm)

Distance between Stapes head to Facial Nerve(mm)	No.of Temporal Bones (%)
1.9	2 (10%)
2.07	9 (45%)
2.3	6 (30%)
2.5	3 (15%)
Mean	2.19mm
SD	0.26

Table 9: Distance between dome of Lateral semicircular canal to Facial Nerve(mm).

Distance between dome of Lateral semicircular canal to Facial Nerve(mm)	No.of Temporal Bones (%)
1.1	2 (10%)
1.22	9 (45%)
1.4	4 (20%)
1.5	5 (25%)
Mean	1.30mm
SD	0.17

DISCUSSION

Contorted anatomy of temporal bone especially in diseased mastoid, makes surgeons' skill more demanding, thus it becomes imperative to identify vital structures to perform successful procedure. Many of the surgical anatomical landmarks [4] are available which must be used as guide for the important structures including facial nerve [5].

Sometimes facial nerve iatrogenic injury is ineludible due to extensive disease completely disfiguring the anatomy especially in recurrent cases, although it more commonly occurs at the hands of an unskilled artist [6] which is further aggravated by dissimilitude course of Facial nerve, which lays open to injury unwittingly [7].

A study by Cawthorne et al on 138 cases revealed intra operative facial palsy were from iatrogenic insult , 47 cases were iatrogenic injury and most common site in 28 cases were second genu and proximal portion of vertical segments [8].

In our study the mean length of tympanic segment of facial nerve was 11.38+/-1.95 mm ranging from 8.5mm to 13.4mm. This was in concurrence with the studies by Rulon and Hallberg [8] and Wilbrand [9]. They reported the length of the tympanic segment of the facial nerve to vary from 8 to 11 mm.

The length of tympanic segment in a study by Mãru *et al*. [10] was 10.25 ± 0.75 mm (range 9.15–12.03 mm), by Kharat *et al*. [11] 9.28 ± 1.13 mm (7–12 mm) and by Yadav *et al*. [12] was 11.1 mm ± 0.88 (9–13 mm).

The length of horizontal segment was 8 mm in a study by Botros [13] which is less as found in our study.

The vertical portion of facial nerve begins from second genu (eminentia pyramidalis) up to stylomastoid foramen exit **(Fig 4)**. The mean length of mastoid segment of facial nerve was 13.98+/-2.32mm (11.5mm to 17.1mm). Similar finding was found in a study by Maru et al [10] 12.2mm, Kharat et al [11] 13.7+/-1.45mm, Dimopoulus et al [14] 13.9+/-1.45mm and Kullman et al [15] reported length of 12.2 mm (range 8.9-16 mm).

The mean angle at second genu was 113.6+/- 13.83 degree (95 to 133 degree **(Fig 5)**. This is similar to the study by Maru et al [10], Wilbrand HF [9], and Kharat et al [11], having angle at second genu ranging from 92-125 degree, 80-100 degree, 95-120 degree respectively.

The mean distance between chorda tympani and facial nerve was 6.56+/- 0.49 mm (6-7.2mm) from its origin till it reaches stapes head area. In revision stapedotomy or stapedectomy, the facial nerve is usually covered by granulation tissue, the risk of the facial nerve injury at tympanic portion over the fenestra vestibuli will be higher [17,18]. If distance between pyramidal eminence, where stapedius tendon is attached and facial nerve is known the risk of facial nerve injury may decrease. Candan et al [19] measured this distance in histologic sections and determined 1.50-2.30 mm. In our study the mean distance between Pyramid to Facial Nerve was 1.38+/- 0.23mm (1.1-1.7mm).

Processus cochleariformis is very important landmark on medial wall, the distance between it and surrounding structures must be known. Wong and Chen [20], and Schaitkin and May [21] declared that processus cochleariformis is a constant landmark to identify the facial nerve even though other landmarks cannot be found by the reason of middle ear pathologies.

The mean distance between Cohleariform process to Facial Nerve was 2.47mm+/-0.10 (range 2.35-2.60mm) **(Fig 2).** The study by Maru et al [10], and Senturk et al [16] showed the distance between choleariform process and facial nerve tympanic segment 0.36-1.98mm and 0.2-1.20 mm respectively.

The mean distance between stapes head to Facial Nerve was 2.19mm+/-0.26 (1.9-2.5mm) **(Fig 2)**.

The seventh cranial nerve runs between the horizontal semicircular canal and the anterior part of oval window. Therefore, during removal of pathologies both risk of labyrinth opening and facial nerve injury can increase. Donaldson and Anson [22] reported that the shortest distance between lateral semicircular canal and facial canal was 1.25 mm (0.92-1.70 mm) on average.

The mean distance between dome of Lateral semicircular canal to Facial Nerve was 1.30mm+/-0.17(1.1-1.5mm).The distance was found to be 2+/-0.5mm, 2-3mm, 0.2-2mm in study done by Maru et al [10], Wilbrand HF [9], Senturk et al [16] respectively.

CONCLUSION

Thorough knowledge of temporal bone surgical anatomy is mandatory to know variable anatomy of facial nerve to prevent iatrogenic injury and further complications. Temporal bone dissection gives adequate knowledge and confidence to surgeon both intra and post operatively. This study gives basic knowledge on intra temporal facial bony canal course and its relation to important landmarks in otological surgery.

Conflicts of Interests: None

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