Original article:

Facial nerve in relation to temporal bone pneumatization – a cadaveric study

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Abstract:

Background - Besides clinical judgment and technical skills, a competent surgeon must also be a good anatomist. This statement is especially important with reference to facial nerve in middle ear. To make situation worse, the middle ear and mastoid pneumatization varies from bone to bone even in the same person, this is what makes mastoid surgery such a difficult task.

Objective - To see whether pneumatization status of temporal bone influences the intratemporal facial nerve

Method - 30 cadaveric temporal bones were dissected. Depending upon the pneumatization of air cells, temporal bones were divided into 2 groups i.e. pneumatized and poorly pneumatized group. The facial nerve along with its branches was exposed from lateral part of 1st genu to outside of stylomastoid foramen.

Results – The average length of mastoid and tympanic segments of facial nerve was found to be 12.6mm and 14.7mm in pnematized specimens and 11.8mm and 13.9mm among poorly pneumatized specimens.

Conclusion - No significant difference was seen in the dimensions of facial nerve among the 2 groups. However, dehiscence of facial nerves was found to be more common in the pneumatized specimens.

Key words: facial nerve, dehiscence, pneumatization, tympanic, mastoid, stylomastoid foramen.

Introduction:

Facial nerve is the nerve of expression, as all the muscles of facial expression are supplied by facial nerve. Damage to facial nerve can lead to depression in life of the patient and can be devastating for a surgeon[1]. The damage may be on part of the surgeon, anatomical variations, dehiscence, trauma and infections. Facial nerve (FN) runs a very long and tortuous course in the temporal bone. The possibility of FN injury might also cause the surgeon to perform inadequate mastoid surgery, resulting in creation of what is called high facial ridge in canal wall down mastoidectomy. The clinical studies reveal that, high facial ridge is one of the most common reasons for surgical failure in canal wall down mastoidectomies. In order to avoid these complications, it is extremely important to know the detailed anatomical relationship of this nerve with surrounding structures within the mastoid bone.

Term ‘pneumatization’, generally refers to the extent of air cells within temporal bone. Temporal bones can be divided into extensively pneumatized, well pneumatized, poorly pneumatized, and finally non-pneumatized or sclerotic bones. The process of pneumatization takes place from perinatal period to puberty, and is genetically determined, though greatly influenced by the environment, to which these bones are exposed during development. The degree of pneumatization varies significantly and there are no two identical temporal bones, even from one person, which is what makes mastoid surgery such a difficult task. Surgeons must know the extent of air cells to be expected in various regions of temporal bone. The surgeon should also know when to stop exenteration of air cells (Tos[2], 1995).

Though facial nerve has been extensively researched and discussed but there are very limited studies on its relation with pneumatization status of the temporal bone. With these considerations this study was planned to know how pneumatization status of the temporal bone influences facial nerve inside the temporal bone.

Material and methods

Thirty formalin fixed adult skull specimens were taken from the dissection hall of the department of Anatomy. The specimens taken were the sagittal sections. No specific racial, age or gender information was available. After removal of soft tissue around temporal bone, the dissection was preceded. Simple mastoidectomy was done as a preliminary step.

In consideration that facial nerve dimensions may be influenced by pneumatization, temporal bones were divided into 2 groups - pneumatized and poorly pneumatized depending upon the presence or absence of various cell groups. The cells observed were mastoid antrum , periantral cells , squamosal cells, tip cells, retrofacial cells, sinodural angle cell, perisinus cells and zygomatic cells. The method of this classification into 2 types of groups has been described elsewhere[3]. Pneumatization was evaluated as being 'diploic' when air cells contained soft tissue in form of bone marrow and 'sclerotic' when there were no grossly visible cells. The bones evaluated as sclerotic and diploic were classified as being poorly pneumatized. When bone contained all types of air cells it was considered to be pneumatized.

Various bony landmarks like Sinus plate, dural plate, horizontal semicircular canal (HSC), digastric ridge, stylomastoid foramen (SMF) were identified. Facial nerve was dissected from SMF to genu just below the HSC and further the tympanic segment was dissected by removing the bony canal wall and ossicles. During the dissection, origin of chorda tympani, any abnormal branching and dehiscence were also noticed. The pyramidal process was identified and length of the tympanic and mastoid segments was measured from this landmark, as facial nerve lies just above it. The length of mastoid segments of facial nerve was measured from stylomastoid foramen to a point in fallopian canal just above the pyramidal process. The tympanic segment was measured from processes cochleariform to the end of second genu. Measurements were taken by using bend wires, scale, divider and calipers.

Observations

1. Out of 30 temporal bones, 17 were right sided and 13 left sided. During drilling various types of cell groups were noticed. The temporal bone was divided into pneumatized or non pneumatized depending upon mastoid air cell pneumatization status. 21 bones were well pneumatized and 9 were poorly or non-pneumatized. Among non pneumatized, 3 bones were completely sclerotic and 6 were diploeic. Various groups e.g. periantral, squamosal, retrofacial, sinodural angle cells (SDA), zygomatic cells,

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tip cells and perisinus air cells were seen in pneumatized bone. Among these mastoid antrum was seen in 100% of the specimens.

2. Average length of mastoid segment of facial nerve was measured and found to be 14.7 mm (range 11-18mm) in the pneumatized bones. In 30% of specimens the length of mastoid segment of facial nerve was found to be between 15-16 mm and in 20%, it was between 17-18 mm. Maximum and minimum length in pneumatized and non pneumatized bones was found to be 18mm and 11mm, 17mm and 12mm respectively. There was no significant difference in length of vertical segment in pneumatized and non pneumatized temporal bones.
3. Average length of the tympanic segment of facial nerve was found to be 12.6 (range 11-15 mm) in pneumatized bones. Anterior part of tympanic segment of facial nerve was found slightly above the cochleariform process in all the cases and then courses in posterior direction to end at 2nd genu below horizontal semicircular canal. Bony wall of horizontal semicircular canal was seen to be protruding laterally over facial nerve in all the specimens. In 50% of specimens, length of tympanic segment was found to be between 12-13 mm, less than 11 mm in 27% of specimen. Maximum and minimum length in pneumatized and non pneumatized bones was fosund to be 15mm and 11, 14 and 10 mm respectively. There was no significant difference in length of tympanic segment of facial nerve in pneumatized and non pneumatized temporal bones.
4. Chorda tympani was found to be arising from mastoid segment of facial nerve at different levels proximal to stylomastoid foramen (SMF). The origin of chorda tympani (CT) nerve varied from 3-10mm proximal to SMF. In 80% of specimens, nerve arose between 3-6 mm proximal to SMF. There was no significant difference in origin of chorda from SMF in pneumatized and non pneumatized bones.
5. The dehiscence of facial nerve was more common in pneumatized specimen (16%) in comparison to poorly pneumatized (7%). Dehiscence was seen in tympanic segment just above the oval window area in all specimens with maximum dehiscence of 2mm. The length of dehiscence was estimated to be 1mm in 3(10%) specimens and 2 mm in 4(13%) specimens.
6. There was no abnormal branching pattern or abnormal bend noticed. There was no congenital anomaly present.

Discussion:

It is well known fact that temporal bone is one of the most complex anatomical parts of human body. The variation in relative position of facial nerve, sigmoid sinus and other middle ear structures can occur in temporal bone. Variation in the pneumatization status of temporal bones is a known fact. An injury of the facial nerve represents otologic surgeon’s greatest fear. Surgeons are cognizant of not only cosmetic and functional consequences of such complications, but of medico legal ramifications as well.

1. All the temporal bones were studied for pneumatization status. 70% of them were pneumatized among which 52% were extensively pneumatized. 20% bones were diploeic and 10% of them were sclerotic.

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Wright had described that approximately 20% of temporal bones are sclerotic. Differences may be because the degree of pneumatization varies significantly (Tos[11], 1995).

2. Tympanic portion of the facial canal runs along labyrinthine wall of tympanic cavity from first genu at the cochleariform process in a posterolateral direction. Its proximity to oval window is of special interest in middle ear surgery. Frequently facial canal forms a bulging ledge above the oval window, thus rendering direct surgical approach to stapes difficult. In present study, only one specimen showed bulging of facial nerve over stapes. Henner[4] (1960) reported a case in which free nerve coursed below the oval window. This was the only such instance encountered in his 4000 temporal bone procedures.

Author	Tympanic segment			Mastoid segment		
	Min.	Max	Avg	Min.	Max	Avg
Kodo and Nori (1974)	8.67	15.6	12.15	11.8	15.7	14.18
Nayak (1988)	8.72	15.0	13.5	11.0	16.0	13.4
Dimopoulos PA(1996)	8.4	14.4	11.4	6.4	20	13.9
Present study						
Pneumatized	11.0	15.0	12.6	11.0	18.0	14.7
Non- pneumatized	10.0	14.0	11.8	12.0	17.0	13.9

Table1: facial nerve dimensions length recorded in various studies

Kudo and Nori[5] (1974) dissected 12 skulls and measured length of facial nerve on both sides. Mean length of the tympanic portion was found to be 12.15mm (range being 8.67-15.6 mm). Nayak[6] (1988) also dissected 15 cadaveric temporal bones and found mean length of tympanic segment was 13.5mm. Length of the tympanic portion reported by Dimopoulos[7] et al (1996) varied from 8.4 to 14.4mm with average of 11.4mm. Mean length in present study was 12.2 mm and is in agreement with these values. Maximum length of tympanic portion in our study was 15mm which was same as that found by Nayak[6].

In all the cases, tympanic segment started just above the cochleariform process, coursing posteriorly in medial wall of middle ear. Lateral end of the horizontal canal protruded over facial canal in all specimens. This finding is similar as reported by Rulon (1962) and Anson[9] (1963).

3. The transition from tympanic into mastoid or vertical segment occurs at the junction of medial and posterior walls of tympanic cavity. It extends from second genu to stylomastoid foramen. Injury to this segment occurs most commonly during mastoidectomy procedures. While lowering facial ridge, fear of damage to facial nerve may result in creation of what is called the high facial ridge in canal wall down mastoidectomies.

The length of mastoid segment as reported by Nayak (1988) was 13.4mm in fifteen fresh cadaveric temporal bones. Kudo and Nori (1974) found mean length of the corresponding portion of facial nerve to be 14.18mm (11.8-15.7 mm). While Dimopoulos (1996) described the length as 13.9mm (6.4-20.0) in radio anatomical study on one hundred and two temporal bones preparations. In present study, vertical segment was 14.3 mm (11-18mm) which is approximately similar to the one recorded by Kudo and Nori.

Nayak had noted that tympanic segment (13.5mm) was longer than mastoid (13.4mm) segment while in present study mastoid segment (14.3 mm) was found longer than tympanic segment (12.2 mm) as recorded by other authors. But combined length of tympanic and mastoid segments in both the studies is similar i.e. 26.5 mm.

4. Dimopoulos et al in the radio- anatomical study found that length of tympanic and mastoid segment of facial nerve was not influenced by mastoid pneumatization. In the present study also, there was no significant difference in length of these segments in relation to pneumatization.

5. Kullman[10] et al (1971) found that *chorda* arises in 25% of specimens within 3mm of stylomastoid foramen unlike the present study. However variability in the level of origin of chorda tympani was seen as observed by Kullman et al (1971) and Anson[11] et al (1972).

6. In early intra uterine life, facial canal appears like a sulcus on the primordial otic capsule. With development of branchial arches, 2^{nd} branchial arch cartilage, the Reichert's cartilage contributes to convert sulcus into canal. This part of canal may persist as cartilage till 1year of life to be replaced by bone later on. In some of the instances closure of canal is never fully accomplished which can persist as dehiscent portion. The dehiscences are a result of failure of ossification progression either along the length of tympanic portion or around its circumference.

S.NO.	**Reference**	**Dehiscence in Series**	**No. of Ears**	**Source**
1	Beddar	25%	52	Gross dissection
2	Mollica	25%	64	Gross dissection
3	Cawthorne	20%	31	Operative observations
4	Kaplan	7%	100	Operative observations
5	Dietzel	57%	211	Histological study
6	Takahashi	74%	160	Histological study
7	Present study	23%	30	Gross dissection

Table2: Incidence of dehiscence of facial canal

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Various authors have reported different incidence of dehiscences (table Baxter, 1971)[12]. This wide difference in incidence may be because of individual variation and methods of study. In present study, the dehiscence was seen in 23% cases which is approximately same as observed by Beddard (25%) and Mollica (25%) using similar method of study. Most of the studies agree that the tympanic portion is the most frequent site of dehiscence. Dimopoulos et al in the radio anatomical study found that 41%of specimens exhibited dehiscence and vary from 0.4-3.1mm in size. But in present study, none of the samples showed dehiscence of 3mm.

Conclusion

70% of the temporal bones were pneumatized and only 10% bones were completely sclerotic. Rest 20% bones belonged to intermediate group called diploeic bones. Average length of the tympanic segment was 12.4 mm ± 1.30 and mastoid segment of facial nerve was 14.5 mm ± 1.99 mm. No abnormal branching pattern or anomaly was detected. However, origin of chorda tympani nerve varied with respect to distance from SMF. Though the sample size is small and it requires further data to support but from the above study; it is evident that type and degree of pneumatization of mastoid bone does not influence length of facial nerve neither the mastoid or tympanic segments.

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