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Original Article

Ear, Nose and Throat Section

Anatomical Variations in the Intratemporal Course of the Facial Nerve in Wet Temporal Bones: A Cross-sectional Study

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ABSTRACT

Introduction: The Facial Nerve (FN) has a complex intratemporal course within the temporal bone and maintains close anatomical relationships with middle ear and mastoid structures, rendering it particularly vulnerable to iatrogenic injury during otologic surgery. Anatomical variations in its course, including facial canal dehiscence and Oval Window (OWL) overhang, may significantly increase surgical difficulty and risk of FN injury.

Aim: To study the anatomical variations in the intratemporal course of the FN in wet temporal bones and correlate them with mastoid pneumatisation patterns.

Materials and Methods: The present cross-sectional study was conducted in the Department of Otorhinolaryngology in the temporal bone dissection laboratory at Dr. D.Y. Patil Medical College and Research Institute, Pune, Maharashtra, India, over 18 months from March 2024 to June 2025. Fifty wet cadaveric temporal bones were dissected under an operating microscope. Mastoid pneumatisation patterns were recorded, and the lengths of the tympanic and mastoid segments were measured. Second Genu (SG) angle, depth from mastoid cortex, degree of descent, facial canal dehiscence, OWL overhang, lateral hump, and key anatomical distances were recorded. Statistical analysis was performed using a Chi-square test.

Results: The majority of specimens showed a pneumatised mastoid pattern 39 (78%), followed by diploeic 6 (12%) and sclerotic 5 (10%) mastoids. Facial canal dehiscence was identified in 6 (12%) specimens, OWL window overhang in 8 (16%), and lateral hump at the SG in 6 (12%). The mean tympanic and mastoid segment lengths were 9.18±1.044 mm and 13.89±1.297 mm, respectively. A statistically significant association was found between mastoid pneumatisation and oval window overhang (p=0.005).

Conclusion: Clinically, significant variations such as facial canal dehiscence, oval window overhang and lateral hump occur in a considerable proportion of cases.

Keywords: Facial canal dehiscence, Iatrogenic injury, Mastoid pneumatisation, Oval window, Tympanic segment

INTRODUCTION

The FN is one of the most surgically significant structures within the temporal bone due to its complex course and close relationship with middle ear and mastoid structures. Even minor anatomical variations can significantly increase the risk of iatrogenic injury during otological procedures such as tympanoplasty, mastoidectomy, and stapedectomy [1,2].

Wet temporal bone dissection remains the gold standard for studying the detailed anatomy of the FN, as it allows accurate three-dimensional visualisation of the nerve and its surrounding structures [3,4]. Despite this, there is limited data from the Indian population using wet temporal bone specimens.

Variations in the intratemporal course of the FN have important implications during procedures such as mastoidectomy, posterior tympanotomy, cochlear implantation, and stapes surgery, where inadvertent injury to the nerve may result in facial paralysis and significant postoperative morbidity [3,4]. Although several cadaveric studies have evaluated FN anatomy, limited Indian studies have specifically assessed the association between mastoid pneumatisation patterns and clinically significant FN variations in wet temporal bones [3-6]. The present study was therefore undertaken to evaluate these anatomical variations and their surgical relevance.

MATERIALS AND METHODS

The present cross-sectional study was conducted at the Department of Otorhinolaryngology in the temporal bone dissection lab in Dr DY Patil Medical College and Research Institute, Pune, Maharashtra, India, from March 2024 to June 2025. A total of 50 temporal bones were obtained from 25 cadavers. Institutional Ethics Sub-Committee approval was obtained prior to commencement of the study (IESC/PGS/2024/118 dated 12/03/2024). The specimens were selected using convenience sampling from the available cadaveric material in the temporal bone dissection laboratory during the study period.

Inclusion and Exclusion criteria: Only temporal bones with intact FN canals and no prior surgical intervention or gross pathology were included. Bones with fractures or obvious anatomical disruption were excluded.

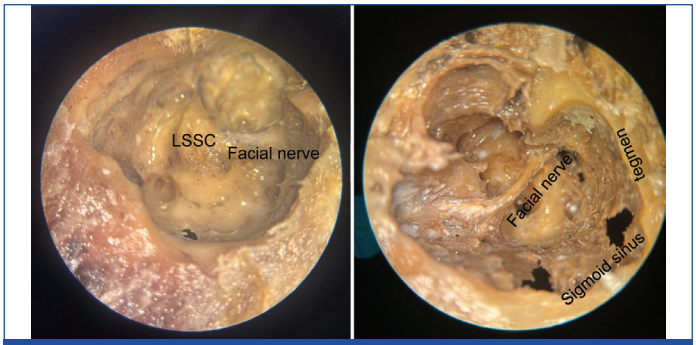
Dissection was performed under an operating microscope (6× to 40× magnification) following a systematic approach. Cortical mastoidectomy was carried out to expose the mastoid segment, followed by opening of the facial recess and tracing of the Tympanic Segment (TS) from the geniculate ganglion to the SG. The labyrinthine segment was exposed by drilling superior to the cochlea and anterior to the vestibule, following standard temporal bone dissection techniques described in previous anatomical studies [3,4].

Representative images demonstrating exposure of the FN and its relationship to adjacent temporal bone landmarks are shown in [Table/Fig-1,2].

Study Procedure

The following parameters were recorded: The lengths of the tympanic and mastoid segments; presence, location, and size of facial canal dehiscence; oval window overhang and its size, presence of a lateral hump at the SG; SG angle; depth of the SG from the mastoid cortex; degree of descent of the mastoid segment; distance from the stylomastoid foramen to the chorda tympani; distance from the chorda tympani to the geniculate ganglion.

The size of facial canal dehiscence and oval window overhang was measured as the maximum linear dimension of the exposed defect

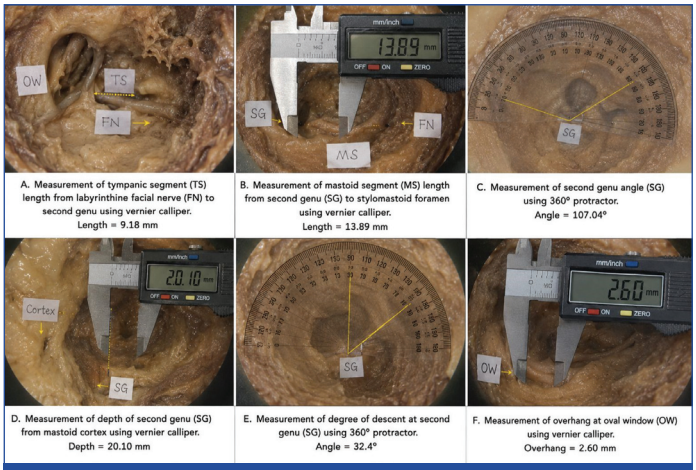


[Table/Fig-1] Exposure of the intratemporal Facial Nerve (FN) during wet temporal bone dissection and its relation to Lateral Semicircular Canal (LSCC)
[Table/Fig-2] The vertical (mastoid) portion of Facial Nerve (FN), demonstrating its course between tegmen superiorly and sigmoid sinus posteriorly (Images from left to right).

or overhanging segment using Vernier calipers with an accuracy of 0.1 mm. Each measurement was recorded three times and the mean value was used for analysis.

Mastoid pneumatisation was classified as pneumatic, diploic, or sclerotic based on the extent of mastoid air cell development. Associations between mastoid pneumatisation patterns and categorical anatomical variations including facial canal dehiscence, oval window overhang, and lateral hump at the SG were evaluated.

Facial canal dehiscence was defined as absence of the bony facial canal covering with exposed FN [1,2]. Oval window overhang was defined as inferior protrusion of the TS partially obscuring the oval window niche [3]. Lateral hump at the SG was defined as a prominent lateral convexity of the facial canal at the SG [4]. Angular measurements were made using a protractor [Table/Fig-3].



[Table/Fig-3]: Representative measurements performed during wet temporal bone dissection. (a) Measurement of Tympanic Segment (TS) length from the labyrinthine FN to the SG using Vernier calipers; (b) Measurement of Mastoid Segment (MS) length from the Second Genu (SG) to the stylomastoid foramen using Vernier calipers; (c) Measurement of SG angle using a 360° protractor; (d) Measurement of the depth of the SG from the mastoid cortex using Vernier calipers; (e) Measurement of the degree of descent at the SG using a 360° protractor; (f) Measurement of Oval Window (OW) overhang using Vernier calipers.

STATISTICAL ANALYSIS

Continuous variables were expressed as mean±standard deviation, while categorical variables were expressed as frequencies and percentages. The Chi-square test was applied to assess the association between mastoid pneumatisation patterns and categorical anatomical variations, including facial canal dehiscence, oval window overhang, and lateral hump. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). A p-value <0.05 was considered statistically significant.

RESULTS

The majority of specimens showed a pneumatised mastoid pattern [39 (78.0%)], followed by diploeic [6 (12.0%)] and sclerotic [5 (10.0%)] patterns [Table/Fig-4]. The mean tympanic and mastoid segment lengths were 9.18 mm and 13.89 mm, respectively.

Facial canal dehiscence was identified in 6 (12.0%) of specimens [Table/Fig-5]. Of the six dehiscent cases, 4 (8%) were located at the TS and 2 (4%) at the oval window region; no dehiscences were observed in either the labyrinthine or mastoid segments. The mean dehiscence size was 2.42±0.376 mm. Overhang at the oval window was present in 16% of specimens with a mean size of 2.60±0.120 mm. A lateral hump at the SG was noted in 12% of specimens.

Parameters	Value
Pneumatisation - Pneumatised, n (%)	39 (78.0%)
Pneumatisation - Diploeic, n (%)	6 (12.0%)
Pneumatisation - Sclerotic, n (%)	5 (10.0%)
Tympanic Segment (TS) length, Mean±SD (mm)	9.18±1.044
Tympanic Segment (TS) length range (mm)	7-11
Mastoid segment length, Mean±SD (mm)	13.89±1.297
Second Genu (SG) Angle, Mean±SD (°)	107.04±7.848
Second Genu (SG) depth from mastoid cortex, Mean±SD (mm)	20.10±1.754
Degree of descent at Second Genu (SG), Mean±SD (°)	32.4±8.6
Stylomastoid foramen to chorda tympani, Mean±SD (mm)	5.13±1.260
Chorda tympani to geniculate ganglion, Mean±SD (mm)	17.96±1.923

[Table/Fig-4]: Pneumatisation pattern and key morphometric parameters.

Variation	Present n (%)	Absent n (%)	Mean Size (mm)
Facial canal dehiscence (overall)	6 (12.0%)	44 (88.0%)	2.42±0.376
• At Tympanic Segment (TS)	4 (8.0%)	—	—
• At oval window region	2 (4.0%)	—	—
• At labyrinthine/mastoid segment	0	—	—
Overhang at oval window	8 (16.0%)	42 (84.0%)	2.60±0.120
Lateral hump at Second Genu (SG)	6 (12.0%)	44 (88.0%)	—

[Table/Fig-5]: Prevalence of clinically significant variations.

Percentages for 'Present' categories were calculated using the total number of specimens exhibiting the variation as the denominator, whereas percentages for 'Absent' categories were calculated using the total number of specimens without the variation as the denominator.

The association between pneumatisation pattern and oval window overhang was the only statistically significant finding in this study (p=0.005) [Table/Fig-6]. Among specimens with oval window overhang, 3 (37.5%) were pneumatised, 2 (25.0%) were diploeic, and 3 (37.5%) were sclerotic.

DISCUSSION

The present study evaluated the morphometric characteristics and anatomical variations of the intratemporal FN in 50 wet temporal bone specimens. The findings were broadly consistent with existing literature. The mean TS length in the present study was 9.18±1.04 mm, which was comparable to the values reported by Kharat RD et al., (9.28 mm) [3] and Gupta N et al., (10.44±1.43 mm) [4]. Similarly, the mean mastoid segment length of 13.89±1.30 mm was comparable to that reported by Kharat RD et al., (13.70 mm) [3] and Gupta N et al. (13.33±2.20 mm) [4].

The high frequency of dehiscence involving the TS observed in the present study reinforces the importance of meticulous surgical dissection in this region. During middle ear and mastoid surgery, the TS is particularly vulnerable because of its close relationship to the oval window, pyramidal eminence, and ossicular chain. Even small areas of bony dehiscence may expose the FN to direct trauma during drilling or instrumentation. Awareness of these variations is

Pneumatisation	Dehiscence absent n (%)	Dehiscence present n (%)	Overhang absent n (%)	Overhang present n (%)	Lateral hump absent n (%)	Lateral hump present n (%)
Diploeic	6 (13.6%)	0	4 (9.5%)	2 (25.0%)	6 (13.6%)	0
Pneumatised	34 (77.3%)	5 (83.3%)	36 (85.7%)	3 (37.5%)	34 (77.3%)	5 (83.3%)
Sclerotic	4 (9.1%)	1 (16.7%)	2 (4.8%)	3 (37.5%)	4 (9.1%)	1 (16.7%)
p-value	0.563		0.005*		0.563	

[Table/Fig-6]: Association of pneumatisation pattern with clinically significant variations.
*Statistically significant (p<0.05). Chi-square test.

Parameters	Present Study (n=50)	Aggarwal U et al., [5]	Ishita et al., [6]	Gupta N et al., [4]	Kharat RD et al., [3]
Tympanic segment (ts) length (mm)	9.18±1.044	5.71	10.40±1.416	10.44±1.4	9.28
Mastoid segment length (mm)	13.89±1.297	9.80	12.34±0.915	13.33±2.2	13.70
Second Genu (SG) Angle (°)	107.04±7.848	–	90°-120° (range)	104.66±7.76	–
Second Genu (SG) depth from cortex (mm)	20.10±1.754	12.6-19.2 (range)	–	–	19.72
Stylomastoid to chorda tympani (mm)	5.13±1.260	–	5.31±0.603	–	–
Facial canal dehiscence (%)	12	–	33 (tympanic)	–	–
Oval window overhang (%)	16	–	–	–	~2

[Table/Fig-7]: Comparison of key parameters with published literature [3-6].

therefore essential to minimise postoperative FN dysfunction and improve surgical safety [3].

The tympanic and mastoid segment lengths in the present study are consistent with those reported by Kharat RD et al., and Gupta N et al., while the notably lower values reported by Aggarwal U et al., likely reflect differences in segment boundary definitions [Table/Fig-7] [3-6]. Variability in morphometric measurements across published studies may be attributed to differences in cadaver preservation techniques, ethnic and population-based anatomical variation, sample size, and measurement methodology. Wet cadaveric temporal bones provide superior soft-tissue preservation and allow more accurate identification of neural relationships when compared with dry temporal bone specimens.

Mastoid pneumatisation has long been recognised as an important anatomical factor influencing middle ear and mastoid architecture. Poorly pneumatised temporal bones are often associated with reduced surgical working space, altered anatomical orientation, and increased technical difficulty during mastoid surgery [7].

Limitation(s)

The present study has certain limitations. The sample size was limited to 50 temporal bones, and all specimens were derived from cadaveric dissection, which may not fully represent in vivo anatomical variations. A further limitation is that 50 temporal bones obtained from 25 cadavers were analysed as the study units. As bilateral temporal bones from the same cadaver were included, observations from the two sides may not be completely independent. This potential clustering may have influenced the estimates of statistical significance. Additionally, histological assessment was not performed, which may have led to underestimation of micro-dehiscences. Future studies with larger sample sizes and incorporation of radiological correlation are recommended to validate these findings. The number of specimens demonstrating oval window overhang was small, which may limit the robustness of categorical association testing.

CONCLUSION(S)

The tympanic and mastoid segments demonstrated relatively consistent anatomical relationships with surrounding middle ear landmarks, supporting their reliability during otologic surgery. Clinically important variations, including facial canal dehiscence, oval window overhang, and lateral hump at the SG, were identified in a considerable proportion of specimens. These findings highlight the importance of detailed anatomical knowledge and careful surgical planning in reducing the risk of iatrogenic FN injury during middle ear and mastoid procedures.

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