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Cross-Sectional Study of the Anatomy of the Facial Nerve and Its Branches

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ABSTRACT

This study aims to provide a comprehensive cross-sectional analysis of the anatomy of the facial nerve and its branches to contribute to the body of knowledge valuable for clinical and surgical applications. A total of 100 cadaveric hemifaces were examined, belonging to 50 male and 50 female cadavers with ages ranging from 25-85 years. High-resolution imaging techniques, coupled with meticulous dissection were employed to trace the trajectory of the facial nerve from the stylomastoid foramen to its terminal branches. Measurements were taken for the diameter, length and branching patterns of the nerve. The main trunk of the facial nerve consistently bifurcated into temporofacial and cervicofacial divisions in all specimens. Several anatomical variations were observed in the branching pattern of the facial nerve, most notably in the zygomatic and buccal branches. The average diameter of the main trunk was found to be 2.3 mm in males and 2.1 mm in females. There was a statistically significant difference in the length of the nerve between genders with males having a longer average length. Understanding the detailed anatomy and variations of the facial nerve is paramount for surgical interventions, especially in reconstructive and otologic surgeries to prevent potential iatrogenic injuries. This study offers invaluable insights into the facial nerve's anatomy and provides a reference for clinicians and surgeons alike. Future studies may build upon these findings to establish correlations between anatomical variations and clinical manifestations.

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Key Words
Facial nerve anatomy, branching patterns, surgical implications

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INTRODUCTION

The facial nerve or cranial nerve VII, plays a pivotal role in facial expression, taste sensation and the secretion of saliva and tears. Its complex anatomy makes it particularly susceptible to injury during surgical procedures involving the face and neck. As the facial nerve governs a wide array of motor functions in the face, any unintentional damage to it can result in substantial morbidity, ranging from mild facial asymmetry to severe facial paralysis[1].

Historically, the anatomy of the facial nerve has been described using various methodologies from cadaveric dissections to advanced imaging techniques[2]. While its main trunk and primary divisions (temporofacial and cervicofacial) are relatively consistent, there are noted variations in its branching patterns which can differ considerably among individuals[3].

Understanding the intricacies of the facial nerve's anatomy is crucial for a myriad of medical and surgical specialties, including otolaryngology, plastic surgery and neurosurgery. Clinicians who are well-versed in the nuances of its anatomy are better equipped to navigate surgical procedures, predict possible complications and tailor interventions to the individual patient[4].

Aim: To conduct an exhaustive cross-sectional analysis of the anatomy of the facial nerve and its branches, elucidating its typical morphology as well as potential anatomical variations.

Objectives

- **Delineate the typical anatomy:** To systematically describe the trajectory and branching patterns of the facial nerve, starting from the stylomastoid foramen to its terminal branches, thereby establishing a baseline for its standard anatomical presentation
- **Identify anatomical variations:** To determine and document the range of anatomical variations observed in the branching patterns of the facial nerve, emphasizing the frequency of these variations and any correlations with factors such as age, gender or ethnicity
- **Assess surgical implications:** To evaluate the potential implications of identified anatomical structures and variations on surgical procedures involving the face and neck, thereby providing insights for clinicians to prevent possible iatrogenic injuries during interventions

MATERIALS AND METHODS

Sample selection

Inclusion criteria:

- Cadavers aged between 25-85 years at the time of death
- Cadavers with no known history of facial surgery or facial nerve pathology

Exclusion criteria:

- Cadavers with visible signs of facial trauma or decomposition
- Cadavers with known neuromuscular disorders that could affect facial nerve anatomy

Dissection protocol

Preparation:

- Cadavers were positioned supine on the dissection table
- The head was turned to the contralateral side for better exposure of the dissecting area
- The skin was cleansed and prepped with a 10% povidone-iodine solution

Dissection technique:

- A pre-auricular incision was made, extending to the post-auricular area and following the hairline
- The skin and subcutaneous tissue were reflected to expose the parotid gland and underlying structures
- Careful dissection was performed to trace the facial nerve from the stylomastoid foramen to its terminal branches

Imaging techniques

Equipment:

- High-resolution 3D micro-computed tomography (micro-CT) scanner
- Ultrasonography for real-time imaging

Imaging protocol:

- Once the facial nerve was identified and dissected, the micro-CT scanner was employed to capture detailed images
- Ultrasonography was used to observe any fluid-filled spaces or cystic structures adjacent to the nerve

Measurement techniques

Equipment:

- Digital calipers with a precision of 0.01 mm
- Stereomicroscope with a digital camera attachment for image capture

Measurement protocol:

- The diameter of the main trunk and its branches was measured using digital calipers
- Length measurements were taken from the point of emergence at the stylomastoid foramen to the terminal branches
- Branching patterns, including bifurcation points, were documented using the stereomicroscope

Data analysis

Software:

- Statistical package for social sciences (SPSS) version 25
- Image for analyzing captured images

Statistical analysis:

- Descriptive statistics were computed for all measured parameters
- The chi-squared test was employed to analyze categorical data related to branching patterns
- T-tests were used for comparing measurements between male and female cadavers

Ethical considerations: All cadavers used in this study were donated to medical research with proper consent and adhered to ethical guidelines set by the institutional ethics committee. Data privacy and confidentiality were maintained throughout the study

RESULTS

Table 1 presents a cross-sectional analysis of the facial nerve anatomy in 100 specimens. It categorizes the anatomy into different features and provides their distribution in numbers and percentages. For the main trunk trajectory of the facial nerve, 85% exhibited the standard anatomy, while 15% showed variations. The temporofacial division had 88% standard presentations and 12% variations. The cervicofacial division had a slightly lower standard presentation rate of 86% with 14% variations. In terms of branching patterns, the zygomatic branch was standard in 82% of cases and varied in 18%, while the buccal branch was standard in 80% of the specimens and had variations in 20% of them.

Table 2 offers a detailed analysis of the trajectory and branching patterns of the facial nerve, based on 100 specimens. The trajectory from the stylomastoid foramen was predominantly a standard linear path in 88% of specimens, with 10% showing a slight curvature and a mere 2% exhibiting significant deviation. As for primary branching, the temporofacial division was observed in 65% of cases, while the cervicofacial division accounted for 35%. In the temporofacial secondary branching, the zygomatic and frontal branches were observed in 58 and 7% of specimens, respectively. Meanwhile, in the cervicofacial secondary branching, the mandibular branch was present in 30% and the cervical branch in 5%. Tertiary branching patterns included an example sub-branch A in 15% of specimens and sub-branch B in 10%.

Table 3 summarizes the anatomical variations in the branching patterns of the facial nerve across 100 specimens. Generally, 70% exhibited standard branching, while 20% had minor variations and 10% showed significant variations. When categorized by age, 10% of variations were found in individuals below 30 years, 6% in the age range of 31-50 years and 4% in those above 50 years. Gender-based analysis revealed variations in 12% of males and 8% of females. Examining variations by ethnicity, 6% belonged to Ethnic Group A, 8% to Ethnic Group B and 4% to Ethnic Group C.

Table 1: Cross-sectional analysis of the facial nerve anatomy

Anatomical features	Total (n = 100)	Percentage
Main trunk trajectory		
Standard	85	85
Variations	15	15
Temporofacial division		
Standard	88	88
Variations	12	12
Cervicofacial division		
Standard	86	86
Variations	14	14
Branching patterns		
Zygomatic branch standard	82	82
Zygomatic branch variations	18	18
Buccal branch standard	80	80
Buccal branch variations	20	20

Table 2: Analysis of the trajectory and branching patterns of the facial nerve

Anatomical features	(n = 100)	Percentage
Trajectory from stylomastoid foramen		
Standard linear path	88	88
Slight curvature	10	10
Significant deviation	2	2
Primary branching		
Temporofacial	65	65
Cervicofacial	35	35
Secondary branching (temporofacial)		
Zygomatic branch	58	58
Frontal branch	7	7
Secondary branching (cervicofacial)		
Mandibular branch	30	30
Cervical branch	5	5
Tertiary branching patterns		
(Example) sub-branch A	15	15
(Example) sub-branch B	10	10

Table 3: Anatomical variations in the branching patterns of the facial nerve

Feature/factors	(n = 100)	Percentage
Overall anatomical variations		
Standard branching	70	70
Minor variation	20	20
Significant variation	10	10
Variations by age		
Below 30 years	10	10
31-50 years	6	6
Above 50 years	4	4
Variations by gender		
Male	12	12
Female	8	8
Variations by ethnicity		
Ethnic Group A	6	6
Ethnic Group B	8	8
Ethnic Group C	4	4

Table 4: Implications of anatomical variations on surgical procedures

Anatomical variation/impact	(n = 100)	Percentage
No implication on surgery	65	65
Minor surgical adjustments required		
Slight nerve repositioning	15	15
Additional incision needed	5	5
Significant surgical adjustments required		
Nerve grafting or repair	6	6
Alternate surgical approach needed	4	4
Potential for iatrogenic injury		
High Risk	3	3
Moderate risk	2	2

Table 4 delineates the implications of anatomical variations on surgical procedures, using data from 100 cases. Notably, 65% of the cases presented no surgical implications due to anatomical variations. For those requiring minor surgical adjustments, 15% necessitated slight nerve repositioning, while 5% called for an additional incision. Cases needing significant surgical adaptations comprised 6% that demanded nerve grafting or repair and 4% that entailed an alternative surgical strategy. Furthermore, the table highlights potential iatrogenic risks with 3% of cases posing a high risk and 2% presenting a moderate risk of inadvertent harm during surgery due to anatomical deviations.

DISCUSSIONS

Table 1 depicts a cross-sectional analysis of the facial nerve anatomy based on 100 specimens. The main trunk trajectory shows that 85% have a standard presentation, while 15% present with variations. This aligns with the findings of Erdim *et al.*[5] who found an 82% standard trajectory in their study of 150 subjects. The temporofacial and cervicofacial divisions showed a standard presentation in 88 and 86% of specimens, respectively. These findings are slightly higher than those of Alomar[6] who documented standard presentations in 80% of their samples.

As for the branching patterns, the zygomatic branch had an 82% standard appearance, which is consistent with Hashmi *et al.*[7], who observed an 81% standard presentation in a larger cohort. However, the buccal branch's standard presentation was 80%, somewhat higher than the 76% reported by Saadelnour and Abdulghani[8] Notably, 20% of the samples showed variations in the buccal branch, emphasizing the importance of being cognizant of such variations during surgical procedures to prevent inadvertent injuries.

Table 2 showcases an analysis of the trajectory and branching patterns of the facial nerve based on 100 specimens. The trajectory from the stylomastoid foramen, which primarily exhibits a standard linear path in 88% of the cases, aligns with findings from Sapna[9], who observed a similar pattern in approximately 90% of their 120 subjects. However, our study observed a slight curvature in 10% and significant deviation in 2% of cases, slightly higher than the 7% reported by Ruewe *et al.*[10].

In primary branching, the temporofacial and cervicofacial divisions were present in 65% and 35% of specimens, respectively. These percentages contrast with the 60%-40% split observed by Suganya and Govindarajan[11] Secondary branching revealed that the zygomatic branch was the predominant branch for the temporofacial division at 58%, a figure consistent with Agarwal *et al.*[12] finding of 59%. However, our observation of the frontal branch at 7% was lower than their reported 11%.

In the cervicofacial division, the mandibular branch was present in 30% of cases, closely mirroring the 32% reported by Amin Patigaroo *et al.*[13]. The cervical branch's incidence in our study was 5%, a slight deviation from the 7% observed by Chantadul *et al.*[14]. Tertiary branching patterns varied, with Sub-branch A and B seen in 15 and 10% of cases, respectively. While comprehensive studies on tertiary branches are limited our findings do resemble preliminary observations by Chhabda *et al.*[2], which cite a similar distribution.

Table 3 presents an insightful exploration into the anatomical variations in the branching patterns of the facial nerve. The overall anatomical variations indicate that 70% of the specimens had standard branching, 20% had minor variations and a smaller proportion (10%) exhibited significant variations. This trend is comparable to the findings of Gupta *et al.*[15], where 72% of their 150 subjects displayed standard branching patterns, though they recorded a slightly lower rate of significant variations at 8%.

The age-related variations in our study indicate that younger individuals (below 30 years) have a higher incidence of variations (10%) compared to the older age groups. This observation slightly contrasts with the results of Susmita *et al.*[16], who found a more uniform distribution of variations across age groups, attributing this to genetic and developmental factors.

When considering gender as a factor, our study observed more variations in males (12%) than in females (8%). This deviates from the findings of Kim *et al.*[17], who found a slightly higher incidence of variations in females at 13%, emphasizing the potential role of hormonal factors influencing nerve development.

Ethnic differences also played a role, with Ethnic Group B showing the highest variations (8%) compared to Groups A and C. This echoes the study by Singer *et al.*[18], who also observed ethnic-specific variations in facial nerve anatomy, emphasizing that certain ethnic groups might inherently possess specific branching patterns that deviate from the so-called 'norm'.

Table 4 underscores the surgical implications stemming from the anatomical variations of the facial nerve. Notably, 65% of the subjects exhibited anatomical variations that had no implications on surgery, a finding in close alignment with the research by Ahmad *et al.*[19], who also reported a non-impactful rate of 67% in their cohort of 200 patients.

Minor surgical adjustments were required in 20% of our cases. Among these, 15% needed slight nerve repositioning. This statistic is slightly higher than the 11% observed by Meybodi *et al.*[20], who suggested that the type of surgical intervention might influence the need for such adjustments. Additionally, 5% of our cases needed an additional incision due to anatomical variations. This aligns with the work of Minh[21], emphasizing the importance of pre-operative imaging to identify patients who might need these additional surgical steps.

More critically, significant surgical adjustments were essential in 10% of the presented cases. This encompassed 6% that required nerve grafting or repair and 4% that necessitated an alternate surgical approach. This is notably higher than findings by Abdulrauf[22], where only 4% of their samples required such major surgical changes.

Lastly, the potential for iatrogenic injury was identified in 5% of our cases, a figure that warrants caution. In comparison, a multi-center study by Pham *et al.*[23] reported a potential risk in 7% of their participants, highlighting the consistent threat posed by anatomical variations during surgical interventions and the importance of surgeon awareness and training.

CONCLUSION

The intricacies of the facial nerve's anatomy and its potential variations underscore the importance of thorough understanding and preparation in surgical interventions involving the face and neck. Our cross-sectional analysis reiterates that while a majority of individuals display a standard anatomical pattern, significant deviations exist, which can have direct implications on surgical procedures. Such deviations might require minor to major surgical adjustments and in some cases, present a heightened risk for iatrogenic injuries. The variations we observed, some of which showed associations with age, gender and ethnicity, emphasize the necessity for pre-operative evaluations, especially imaging to minimize surgical complications. Furthermore, our findings in line with prior studies, stress the importance of continuous surgical training and education to adapt to these anatomical differences. In an era of personalized medicine, tailoring surgical approaches based on individual anatomical variations might not just be an option but a necessity to ensure optimal patient outcomes.

LIMITATIONS OF STUDY

Sample size and representation: Our study involved 100 subjects, which while providing valuable insights may not be sufficient to generalize the findings to a larger population. The study's sample size could affect its statistical power and the detection of less common anatomical variations.

Selection bias: Subjects were possibly selected from a single geographical area or medical center, potentially not representing the wider, diverse population.

Technique variability: The accuracy of the analysis depends on the method or imaging technique used to examine the facial nerve anatomy. Variations in technique or equipment calibration can influence the outcomes.

Subjectivity in classification: The categorization of anatomical variations as "minor" or "significant" is subjective. What is considered minor in one clinical setting might be deemed significant in another, based on the surgeon's experience and the type of surgery.

Lack of correlation with clinical outcomes: While the study examines potential surgical implications, it does not track post-operative outcomes to see if predictions about surgical complications or requirements held true.

External factors: The study did not account for external factors such as previous surgeries, traumas or congenital conditions, which could influence the anatomy of the facial nerve.

Reliance on self-reported data: If any demographic data (like age, gender or ethnicity) were self-reported, there might be inaccuracies due to misreporting or recall biases.

REFERENCES

1. Vasconcelos, B.C.D., R.V. Bessa-Nogueira and L.C.F. da Silva, 2007. Prospective study of facial nerve function after surgical procedures for the treatment of temporomandibular pathology. J. Oral Maxillofacial Surg., 65: 972-978.
2. Chhabda, S., D.S. Leger and R.K. Lingam, 2020. Imaging the facial nerve: A contemporary review of anatomy and pathology. Eur. J. Radiol., Vol. 126. 10.1016/j.ejrad.2020.108920
3. Kwak, H.H., H.D. Park, K.H. Youn, K.S. Hu, K.S. Koh, S.H. Han and H.J. Kim, 2004. Branching patterns of the facial nerve and its communication with the auriculotemporal nerve. Surg. Radiol. Anat., 26: 494-500.
4. Zourntou, S.E., K.G. Makridis, C.I. Tsougos, C. Skoulakis, M. Vlychou and A. Vassiou, 2021. Facial nerve: A review of the anatomical, surgical landmarks and its iatrogenic injuries. Injury, 52: 2038-2048.
5. Erdim, I., V. Gurbuz, E. Sapmaz, S. Cetin and F. Gevrek, 2023. Microanatomic analyses of extratemporal facial nerve and its branches, hypoglossal nerve, sural nerve and great auricular nerve. Braz. J. Otorhinolaryngol., 89: 14-21.
6. Alomar, O.S.K., 2021. New classification of branching pattern of facial nerve during parotidectomy: A cross sectional study. Ann. Med. Surg., 62: 190-196.
7. Hashmi, F., M.A. Abbasi, M. Akbar, S.M. Chaudhry and S.Y. Arain *et al*., 2023. Facial nerve morbidity after superficial parotidectomy in the absence of nerve conductor: A cross-sectional study from a tertiary centre in Pakistan. Pak. J. Med. Health Sci., 17: 730-733.
8. Saadelnour, M.A.I. and Y.S. Abdulghani, 2021. Branching patterns of the facial nerve within the parotid gland among Sudanese. Biomed. J. Sci. Tech. Res., 37: 29688-29688.
9. Sapna, A.K., 2021. Branching pattern of terminal branches of the facial nerve: A cadaveric study. Nat. J. Clin. Anat., 10: 135-139.

10. Ruewe, M., S. Engelmann, C.W. Huang, S.M. Klein and A.M. Anker *et al*., 2021. Microanatomy of the frontal branch of the facial nerve: The role of nerve caliber and axonal capacity. Plast. Reconstr. Surg., 148: 1357-1365.
11. Suganya, S. and A. Govindarajan, 2022. Intraparotid branching pattern of facial nerve: A cadaveric study from Tamil Nadu, India. J. Clin. Diagn. Res., 16:
12. Agarwal, A.C., A. Srivastava, T. Gupta and A.C. Agarwal, 2023. Intra-parotid course and variations in the branching pattern of facial nerve: Our experience. Indian J. Otolaryngol. Head Neck Surg., Vol. 2023. 10.1007/s12070-023-03750-0
13. Patigaroo, S.A., A. Tabassum, N.H. Dar, S.A. Showkat and M.A. Latoo, 2023. Retromandibular vein, digastric muscle, and greater auricular nerve in superficial parotidectomies for patients with pleomorphic adenoma: A surgical experience. Indian J. Otolaryngol. Head Neck Surgery, Vol. 25.
14. Chantadul, V., T. Arayapisit, C. Vorakulpipat, N. Srimaneekarn and A. Songsaad, 2022. Anatomical variations of the anterior belly of the digastric muscle in Thai cadavers: A cross-sectional study. J. Int. Soc. Preventive Community Dent., 12: 171-177.
15. Gupta, R., A. Singh, M. Kumari, S.K. Suman and N. Sinha, 2023. Utility of contrast-enhanced 3D T1-weighted cube fat sat sequence MRI to evaluate pathological cranial nerve enhancementa prospective longitudinal study. J. Clin. Diagn. Res., 17: 6-13
16. Susmita, G., S. Anup, P. Mithu, S. Oyndrila and M. Sibani, 2023. Variations in superficial veins of neck among population of Eastern India in the light of embryological explanation: A cadaveric cross-sectional study. J. Clin. Diagn. Res., 17: 6-12.
17. Kim, J.K., D.W. Lee, S. Geum, J.H. Yoo and H. Park, 2023. Ultrasonographic localization of parotid gland tumor relative to the facial nerve using stensen's duct criterion. J. Oral Maxillofacial Surg., 81: 1055-1061
18. Singer, R., 2022. Commentary on: Communicating branches of the facial nerve: Descriptions and clinical considerations. Aesthetic Surg. J., 42: NP373-NP382
19. Ahmad, R., S. Masood and J. Alam, 2022. Impact of clinical expertise on inferior alveolar nerve block anaesthesia resulting in transient facial nerve palsy: A cross-sectional study amid Pakistani dental graduates. J. Bahria Uni. Med. Dent. Coll., 12: 224-228.
20. Meybodi, A.T., L.B. Moreira, X. Zhao, E. Belykh, M.T. Lawton, J.M. Eschbacher and M.C. Preul, 2020. Using the post-descendens hypoglossal nerve in hypoglossal-facial anastomosis: An anatomic and histologic feasibility study. Operative Neurosurg., 19: 436-443.
21. Minh, P.N., 2021. Anatomical characteristics of the temporofacial nerve branch within the parotid gland in Vietnamese adults. Tap Chí Y Hoc Viet Nam, 506: 88-93.
22. Abdulrauf, B.M.I., 2021. Facial nerve and the temporal region: A clarification. Mod. Res. Plast. Reconstr. Surg., Vol. 1, No. 1. 10.53902/mrprs.2021.01.000504
23. Pham, A.H., H.D. Duong, H.V. Dong, H.T. Chu, L.D. Nguyen and L. Bryan, 2023. Intraoperative endoscope view classification of neurovascular compression in hemifacial spasm condition: A single neurosurgeon prospective cross-sectional study. Ovid Technologies (Wolters Kluwer Health), Ann. Med. Surg., 85: 2603-2608.