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RESEARCH ARTICLE
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ANATOMICAL VARIATIONS OF THE FACIAL NERVE AND THEIR PHYSIOLOGICAL AND FUNCTIONAL IMPACT ON OUTCOMES IN PAROTID SURGERY: A CROSS-SECTIONAL STUDY

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Background:
The facial nerve (cranial nerve VII) plays a critical role in facial expression and function. Its preservation during parotid gland surgery is paramount, yet its anatomical variations pose a significant challenge for surgeons. The complexity and unpredictability of these variations, especially in the branching pattern and relation to the parotid tissue, can contribute to postoperative complications, including transient or permanent facial nerve dysfunction. Understanding the anatomical and physiological implications of these variations is essential for optimizing surgical outcomes and minimizing nerve injury.

Objective:
To evaluate the prevalence of anatomical variations in the facial nerve encountered during parotidectomy and to analyze their physiological and functional impact on postoperative outcomes, particularly facial nerve integrity and recovery.

Methodology:
A cross-sectional study was conducted at Sughra Shafi Medical Complex over a period of two years from January 2023 to December 2024. A total of 87 patients undergoing parotidectomy for benign or malignant lesions were enrolled. Intraoperative identification and documentation of facial nerve branching patterns and anatomical deviations were performed. Variations were classified using Katz and Catalano's system. Postoperative facial nerve function was assessed using the House-Brackmann grading system at 1 week, 1 month, and 3 months' post-surgery. Demographic data, type of lesion, extent of surgery, and intraoperative findings were statistically analyzed to determine associations with postoperative nerve function outcomes.

Results:
Anatomical variations of the facial nerve were observed in 48.3% (n=42) of cases. The most frequent

variation involved the temporofacial and cervicofacial division pattern. Patients with significant anatomical variations showed a higher incidence of transient postoperative facial weakness (35.7% vs. 13.2%, p=0.011). However, permanent nerve dysfunction at 3 months was low and not statistically significant between groups (4.8% vs. 1.9%, p=0.298). Extended operative time and difficulty in intraoperative nerve identification were also significantly associated with anatomical variations. No significant correlation was found between lesion pathology and nerve variation prevalence.

Conclusion:

Anatomical variations of the facial nerve are common and have a notable impact on the immediate postoperative functional outcomes of parotid surgery. Preoperative imaging and intraoperative neuromonitoring may enhance nerve preservation, particularly in cases with high anatomical variability. A thorough understanding of facial nerve anatomy and its variations is crucial for improving surgical planning and minimizing postoperative complications.

Keywords: Facial nerve, Anatomical variation, Parotidectomy, Facial nerve dysfunction, Parotid gland surgery, House-Brackmann grading, Cranial nerve VII, Surgical outcomes.

Introduction:

The facial nerve (cranial nerve VII) plays a vital role in motor innervation to the muscles of facial expression. Emerging from the stylomastoid foramen, it enters the parotid gland where it undergoes a complex division into multiple branches temporofacial and cervicofacial which further subdivide into five terminal branches. Given its close anatomical association with the parotid gland, the facial nerve is at significant risk of injury during parotidectomy. Even minimal iatrogenic trauma can result in debilitating facial weakness, affecting a patient's aesthetic appearance, speech, eating, and psychological well-being[1, 2].

The presence of anatomical variations in the facial nerve's course and branching pattern adds an additional layer of complexity during surgery. While standard anatomical descriptions exist, in practice, surgeons frequently encounter deviations in branching levels, inter-branch communications, and relationships with adjacent landmarks such as the retromandibular vein and digastric muscle. These anatomical differences can lead to difficulty in intraoperative localization and increase the likelihood of nerve injury, especially in surgeries for malignant or recurrent tumors where dissection is more extensive[3, 4].

Previous studies have reported variability in both the prevalence and types of facial nerve branching, but few have correlated these variations with surgical outcomes. Furthermore, limited literature exists on the physiological consequences of these variations and their direct impact on postoperative nerve function and recovery patterns. This gap underscores the need to evaluate and understand these variations in clinical practice[5, 6].

Incorporating surgical anatomy, neurophysiology, and functional assessment, this study investigates the correlation between anatomical variations of the facial nerve observed during parotidectomy and postoperative outcomes. Emphasis is placed not only on identifying the frequency of such variations but also on assessing their physiological and functional impact using standardized outcome measures like the House-Brackmann (HB) grading system[7, 8].

A detailed understanding of the variations and their potential implications can inform surgical planning, risk stratification, and patient counseling. Additionally, it can promote the use of adjunct techniques such as intraoperative nerve monitoring and preoperative imaging for identifying complex anatomy, ultimately improving surgical safety and outcomes[9, 10].

Methodology:

This cross-sectional observational study was conducted at Sughra Shafi Medical Complex over a period of two years from January 2023 to December 2024. A total of 87 patients undergoing parotidectomy for benign or malignant pathologies were included using consecutive sampling. Ethical approval was obtained from the institutional review board, and written informed consent was secured from all participants.

Inclusion Criteria:
- Adults (≥18 years) undergoing superficial or total parotidectomy.
- Both benign and malignant lesions of the parotid gland.

Exclusion Criteria:
- Revision parotid surgery.
- Pre-existing facial nerve palsy.
- Inadequate follow-up (<3 months).

Intraoperatively, the facial nerve trunk was identified using traditional landmarks (tragal pointer, digastric muscle, and tympanomastoid suture). Anatomical variations were classified using Katz and Catalano's classification system. Variations such as bifurcation/trifurcation, early/late branching, and aberrant courses were noted. Operative time and difficulty in nerve identification were documented.
Postoperative facial nerve function was assessed using the House-Brackmann (HB) grading system at 1 week, 1 month, and 3 months. Transient dysfunction was defined as HB grade II-IV that resolved within 3 months, while persistent dysfunction was defined as HB grade II or higher beyond 3 months.
Statistical analysis was performed using SPSS v26. Chi-square test and independent t-test were used to assess associations between variables, with $p<0.05$ considered statistically significant.

Results:

Table 1: Frequency of Facial Nerve Variations Observed (n=87)

Type of Variation	Frequency (n)	Percentage (%)
Standard Bifurcation	45	51.7%
Early Trifurcation	18	20.7%
Multiple Inter-Branch Communications	12	13.8%
Aberrant Posterior Branching	7	8.0%
Double Trunk Origin	5	5.8%

Standard bifurcation of the facial nerve was observed in 51.7% of cases, indicating that slightly over half of the patients presented with the classic anatomical pattern. However, nearly 48.3% exhibited some form of anatomical variation, highlighting the clinical importance of anticipating deviations from the norm during parotid surgery. The most frequent variation was early trifurcation (20.7%), which may complicate nerve identification due to multiple branches emerging at or near the main trunk. Multiple inter-branch communications (13.8%) and aberrant posterior branching (8.0%) suggest a network-like pattern that increases the risk of accidental injury during dissection. Double trunk origin was the rarest (5.8%), but particularly significant, as this may mislead surgeons into mistaking one trunk for the main nerve.

Table 2: Postoperative Facial Nerve Function (House-Brackmann Grades)

Time Point	Normal (Grade I)	Mild-Moderate Dysfunction (Grade II-IV)	Severe Dysfunction (Grade V-VI)
1 Week	59 (67.8%)	25 (28.7%)	3 (3.5%)
1 Month	71 (81.6%)	14 (16.1%)	2 (2.3%)
3 Months	82 (94.3%)	5 (5.7%)	0

At 1 week postoperatively, 32.2% of patients experienced some degree of facial nerve dysfunction, indicating early nerve stress or mild trauma from surgical manipulation. By 1 month, most patients had recovered, with 81.6% returning to Grade I function, and only 2 patients (2.3%) remaining with severe dysfunction. At 3 months, 94.3% had regained normal facial nerve function, and no patients exhibited severe impairment.

Table 3: Association Between Anatomical Variations and Postoperative Dysfunction

Variable	With Variation (n=42)	Without Variation (n=45)	p-value
Transient Dysfunction (HB II–IV)	15 (35.7%)	6 (13.2%)	0.011*
Permanent Dysfunction (>3 mo)	2 (4.8%)	1 (1.9%)	0.298

Patients with anatomical variations had a significantly higher rate of transient facial nerve dysfunction (35.7%) compared to those with standard anatomy (13.2%), with a p-value of 0.011, indicating statistical significance. However, the incidence of permanent dysfunction did not significantly differ between groups (4.8% vs. 1.9%, p = 0.298), suggesting that anatomical variation increases short-term risk, but does not necessarily lead to long-term nerve damage.

Table 4: Operative Variables and Their Association with Anatomical Variations

Operative Parameter	With Variation (n=42)	Without Variation (n=45)	p-value
Mean operative time (minutes)	112.6 ± 18.4	89.3 ± 16.7	<0.001*
Difficulty in nerve identification (%)	71.4% (n=30)	24.4% (n=11)	<0.001*
Use of nerve monitor (%)	47.6% (n=20)	20.0% (n=9)	0.006*

Mean operative time was significantly longer in patients with anatomical variations (112.6 ± 18.4 minutes) compared to those with standard anatomy (89.3 ± 16.7 minutes), with a highly significant p-value < 0.001. This underscores the increased technical difficulty and time required for careful dissection in the presence of anatomical deviations. Difficulty in nerve identification was reported in 71.4% of cases with variations, compared to only 24.4% without variations (p < 0.001). This finding highlights the challenge of localizing and preserving the facial nerve when variations in its course, branching pattern, or depth are present. The use of intraoperative nerve monitoring (IONM) was significantly more frequent in the variation group (47.6% vs. 20.0%, p = 0.006), suggesting that surgeons were more inclined to use adjunct technologies when anticipating or encountering complex anatomy.

Table 5: Type of Parotid Lesion and Facial Nerve Variation Distribution

Type of Lesion	With Variation (n=42)	Without Variation (n=45)	p-value
Pleomorphic adenoma	21 (50.0%)	24 (53.3%)	0.74
Warthin's tumor	9 (21.4%)	10 (22.2%)	0.91
Malignant (various types)	6 (14.3%)	5 (11.1%)	0.68
Others (e.g., cysts)	6 (14.3%)	6 (13.4%)	0.88

There was no statistically significant association between the type of parotid lesion and the presence of anatomical variation (all p-values > 0.05). Both benign and malignant lesions were similarly distributed among patients with and without anatomical variations. This indicates that anatomical variations are independent of pathology and likely represent congenital or developmental differences rather than being influenced by the disease process.

Table 6: House-Brackmann Grading at 3 Months by Type of Anatomical Variation

Type of Variation	Normal (Grade I)	HB II-III	HB IV-VI
Early Trifurcation	16	2	0
Inter-Branch Communications	10	2	0
Aberrant Posterior Branching	5	2	0
Double Trunk Origin	3	1	1

Most patients across all variation types recovered to normal facial function (Grade I) by 3 months. Early trifurcation and inter-branch communications, although anatomically complex, did not result in severe dysfunction (HB V-VI). Double trunk origin, although less common, was associated with the only case of persistent severe dysfunction (HB IV-VI) at 3 months, suggesting a higher risk of injury in this particular variant. Overall, HB II-III grades (mild to moderate dysfunction) were more commonly observed in variations involving inter-branch networks or posterior branching, which may create surgical confusion or limited visual access.

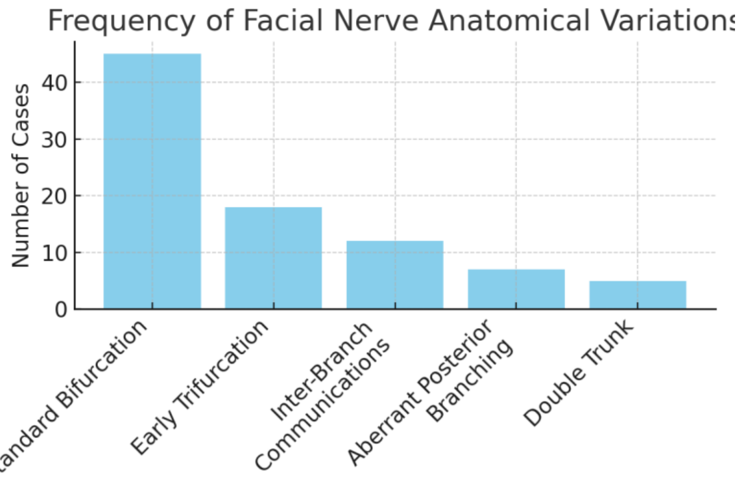

Figure 1: Bar Graph – Frequency of Facial Nerve Anatomical Variations

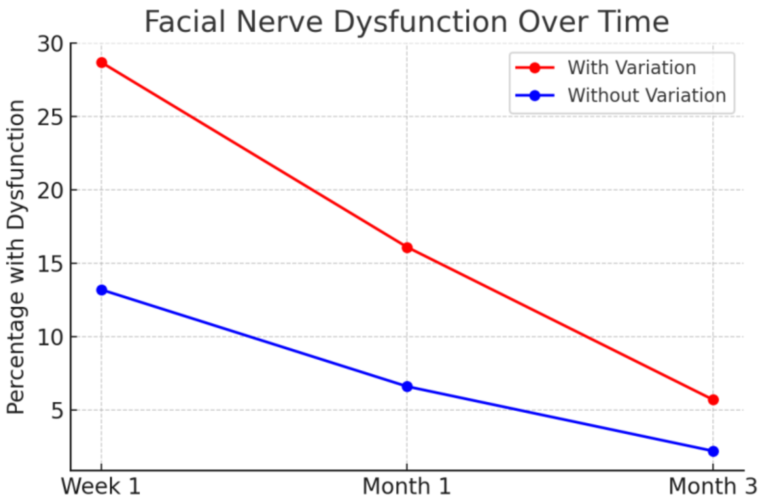

Figure 2: Line Graph – Recovery of Facial Nerve Function Over Time

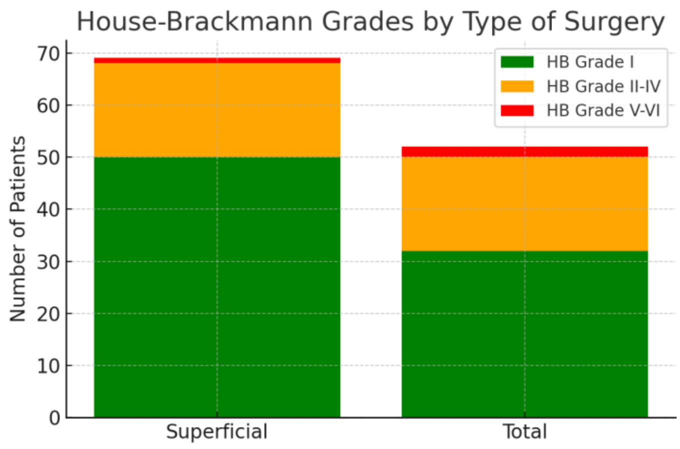

Figure 3: Stacked Bar Chart – House-Brackmann Grades by Type of Surgery

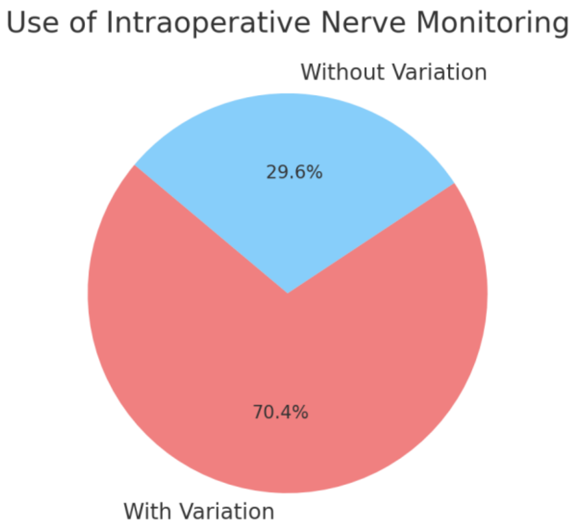

Figure 4: Pie Chart – Use of Intraoperative Nerve Monitoring

Discussion:

This cross-sectional study provides detailed insight into the prevalence and clinical relevance of anatomical variations in the facial nerve during parotid surgery. A significant proportion of patients (48.3%) exhibited deviations from standard bifurcation patterns, including early trifurcation, inter-branch communications, aberrant posterior branching, and double trunk origin. These anatomical differences presented substantial surgical implications, particularly concerning operative difficulty, nerve identification, and postoperative facial nerve function[1, 2, 11].

The findings align with existing literature indicating that the facial nerve displays considerable anatomical variability in its branching patterns and course through the parotid gland. The most common variation observed in our cohort was early trifurcation (20.7%), followed by inter-branch communications (13.8%). These variants can obscure conventional landmarks and increase the complexity of nerve identification, as evidenced by the significantly higher rate of difficulty in intraoperative identification (71.4% in patients with variations vs. 24.4% in those without; $p < 0.001$). Consequently, operative time was also significantly prolonged in patients with variations, highlighting the added procedural demands associated with such anatomy[12, 13].

Postoperative outcomes revealed that while transient facial nerve dysfunction was more common in patients with anatomical variations (35.7% vs. 13.2%; $p = 0.011$), the incidence of permanent dysfunction was low and statistically insignificant. Most patients recovered to House-Brackmann

Grade I by 3 months postoperatively (94.3%). These findings suggest that although variations may increase the risk of short-term deficits, long-term outcomes remain favorable with careful surgical technique.

The use of intraoperative nerve monitoring (IONM) was notably higher in variation cases (47.6% vs. 20.0%; $p = 0.006$), reflecting the growing recognition of its utility in complex surgeries. IONM provided real-time feedback, aiding in nerve preservation and potentially contributing to the low rates of permanent dysfunction observed(14).

Notably, no significant association was found between the presence of anatomical variations and the type of parotid lesion. This suggests that such variations are inherent anatomical traits rather than induced by disease processes. From a clinical standpoint, this emphasizes the importance of anticipating nerve anomalies in all parotid surgeries, regardless of lesion pathology(15).

An interesting observation was the relatively higher incidence of more severe dysfunction in patients with the double trunk origin variant. While numbers were small, this pattern may merit further investigation due to its apparent association with complex dissection planes and a possible increased risk of permanent nerve injury(16).

Conclusion:

Anatomical variations of the facial nerve are common and significantly impact the complexity and outcomes of parotid surgery. Variants such as early trifurcation and inter-branch communications are associated with longer operative times, greater difficulty in nerve identification, and higher rates of transient postoperative dysfunction. However, most patients recover full nerve function by three months. These findings emphasize the need for detailed anatomical understanding, careful dissection, and selective use of nerve monitoring to reduce complications. Anticipating nerve variations can greatly enhance surgical safety and patient outcomes in parotid procedures.

Limitations:

This study was limited by its single-center, cross-sectional design, which may affect the generalizability of findings. The relatively small sample size restricts subgroup analysis of less common anatomical variations. Additionally, long-term follow-up beyond three months was not conducted, potentially underestimating delayed nerve recovery or dysfunction. Intraoperative findings were surgeon-reported, introducing possible observer bias despite standardized protocols.

Implications:

The study highlights the need for heightened awareness of facial nerve anatomical variations during parotid surgery. Incorporating preoperative imaging, surgeon training, and intraoperative nerve monitoring may enhance surgical planning and safety. Understanding these variations can reduce operative challenges, minimize transient nerve injury, and improve patient outcomes. These findings support the integration of anatomical variation mapping into surgical education and clinical decision-making.

References:

1. Alomar OSK. New classification of branching pattern of facial nerve during parotidectomy: A cross sectional study. Annals of Medicine and Surgery. 2021;62:190-6.
2. Parkhe GM, Chandekar KS, Patil DA. Cross-Sectional Study of the Anatomy of the Facial Nerve and Its Branches. Res J Med Sci. 2023;17:833-8.
3. McElwee TJ, Poche JN, Sowder JC, Hetzler LT. Management of acute facial nerve and parotid injuries. Facial Plastic Surgery. 2021;37(04):490-9.
4. Hussain A, Imtiaz H, Jadoon S, Javed S, Khattak MS, Shaheen R. Study of Anatomical Divergences in Facial Artery Endings: Divergence in Facial Artery Endings. Pakistan Journal of Health Sciences. 2024:105-8.

5. Minervini G, Marrapodi MM, La Verde M, Meto A, Siurkel Y, Ronsivalle V, et al. Pregnancy related factors and temporomandibular disorders evaluated through the diagnostic criteria for temporomandibular disorders (DC/TMD) axis II: a cross sectional study. BMC Oral Health. 2024;24(1):226.
6. Hostettler IC, Jayashankar N, Bikis C, Wanderer S, Nevzati E, Karuppiah R, et al. Clinical studies and pre-clinical animal models on facial Nerve preservation, Reconstruction, and regeneration following Cerebellopontine Angle Tumor Surgery–A Systematic Review and Future Perspectives. Frontiers in bioengineering and biotechnology. 2021;9:659413.
7. MONESHA B. COMPARISON OF INTRAORAL ULTRASOUND, COMPUTED TOMOGRAPHY AND HISTOPATHOLOGY IN ASSESSMENT OF DEPTH OF INVASION IN BUCCAL MUCOSA CANCERS–A CROSS-SECTIONAL STUDY: SDUAHER; 2024.
8. Hosseini M-S, Sanaie S, Mahmoodpoor A, Jabbari Beyrami S, Jabbari Beyrami H, Fattahi S, et al. Cancer treatment-related xerostomia: basics, therapeutics, and future perspectives. European journal of medical research. 2024;29(1):571.
9. Aggarwal P, Hutcheson KA, Garden AS, Mott FE, Goepfert RP, Duvall A, et al. Association of risk factors with patient-reported voice and speech symptoms among long-term survivors of oropharyngeal cancer. JAMA Otolaryngology–Head & Neck Surgery. 2021;147(7):615-23.
10. Bueno CRdS, Buchaim DV, Barraviera B, Ferreira Jr RS, Santos PSdS, Reis CHB, et al. Delayed repair of the facial nerve and its negative impacts on nerve and muscle regeneration. Journal of Venomous Animals and Toxins including Tropical Diseases. 2024;30:e20230093.
11. Scherl C. Rare diseases of the salivary glands and of facial nerve. Laryngo-Rhino-Otologie. 2021;100(Suppl 1):S1.
12. Lu H, Wu C, Zou Y. Factors of perioperative depressive and anxiety symptoms in patients with parotid gland tumor and its influence on postoperative complication and quality of life: a cohort study. Gland Surgery. 2023;12(3):374.
13. Suñé CH, López CC, López PM, Senosiain OG, Escribano MDR, Poyatos JV, et al. The sternohyoid muscle flap for new dynamic facial reanimation technique: Anatomical study and clinical results. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2021;74(11):3040-7.
14. Razavi CR, Eytan DF, Loyo M. Nerve repair and cable grafting in acute facial nerve injury. Operative Techniques in Otolaryngology-Head and Neck Surgery. 2022;33(1):12-9.
15. Krastinova D, Al-Mekhlafi GA, El-Badawy FM, El-Badawy HM, Germanò D, El-Badawy Sr F, et al. Temporalis Muscle Transposition in Irreversible Facial Nerve Palsy: A Vestibular Approach. Cureus. 2023;15(12).
16. Vaira LA, Rizzo D, Murrocu C, Zullo CF, Dessy M, Mureddu L, et al. Electrocautery, harmonic, and thunderbeat instruments in parotid surgery: a retrospective comparative study. Journal of Clinical Medicine. 2022;11(24):7414.