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Original Research Article

NEUROVASCULAR ANATOMY OF THE HEAD AND NECK: IMPLICATIONS FOR SURGICAL PLANNING

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Abstract: ***Background:*** The neurovascular anatomy of the head and neck is a very important factors that require a clear comprehension of the anatomy to have safe and effective surgery. Circumstances of anatomical differences in arterial branching, venous drainage, and cranial nerve course might play a major role in the planning and decision-making of operations and rates of complications. Their ignorance of these differences can lead to a heightened risk of bleeding, nerve damage, extended working days, and postoperative malpractice. ***Objectives*** To determine the effect of elaborate preoperative neurovascular assessment on the outcomes of surgery, complication rates, and safety of surgery among patients undergoing head and neck surgery. ***Methodology*** This Prospective Observational Study Conducted at Department Of Anatomy Rehman College Of Dentistry Peshawar From Jan 2025 To June 2025. involving 100 patients who were going to get an elective head and neck operation in a tertiary care hospital. Preoperative contrast-enhanced CT angiography and Doppler ultrasonography were performed on all the patients to assess the arterial patterns, venous anatomy, and nerve relationships. The results of imaging were compared to the results obtained during intraoperative conditions and three months were followed up on the patients after the operation. Mean standard deviation of continuous variables, percentages of categorical variables were used to statistically analyze the data, and $p < 0.05$ was taken to be statistically significant. ***Results*** The study population comprised 58 males and 42 females, with a mean age of 46.8 ± 12.4 years. Neurovascular anatomical variations were observed in 37% of patients, most commonly involving the external carotid artery (21%). Patients with vascular variations had significantly greater intraoperative blood loss (520 ± 110 mL vs. 390 ± 95 mL; $p = 0.003$) and longer operative time (145 ± 25 vs. 120 ± 20 minutes; $p = 0.02$). Transient cranial nerve deficits occurred in 8% of cases. Preoperative vascular mapping significantly reduced unexpected intraoperative findings ($p = 0.01$). ***Conclusion*** Detailed preoperative neurovascular evaluation is more effective in improving the planning of surgery, complications, and overall safety of operations in head and neck surgery.

Keywords: Neurovascular anatomy; Head and neck surgery; Anatomical variations; Surgical planning.

INTRODUCTION

The head and neck are one of the most anatomically complicated parts of the human body. It has a high concentration of critical vascular, neural, muscular, and glandular tissues in a relatively compact area. Complexity between the arteries and veins, cranial nerves, lymphatic and fascial planes presents a great challenge when practicing surgery. Even the slightest differences in the anatomy could result in major intraoperative problems, such as massive blood loss, damage to nerves, stroke, obstruction of the airways, and permanent impairment of functionality [1,2].The common carotid arteries and vertebral arteries provide the major part of the arterial supply in the neck and the head. A major landmark in surgery is the division of the common carotid artery into external and internal carotid arteries. The external carotid artery branches out to provide the thyroid gland, tongue, face, scalp, and maxillofacial structures. These differences in the patterns of branching are normal and can affect the exposure to the surgery, the vascular control, and reconstructive planning. On the same note, the vertebral arteries, which pass along the transverse foramina between vertebrae, are prone to injury during cervical spine surgeries and skull base surgery [3,4]. The drainage of the area is also important. The internal jugular vein, which is in the carotid sheath along with the common carotid artery and vagus nerve, makes a significant contribution to cerebral venous flow [5]. Damage to this structure can cause fatal bleeding or air embolism. Another anatomical consideration of critical interest is the pterygoid venous plexus and its relation with the cavernous sinus, since an infection may spread intracranially [6].The cranial nerves passing through the head and neck are very vulnerable to surgical trauma. In parotid surgery, the facial nerve is of special concern, and in neck dissection and carotid surgery, there is the risk of damaging the hypoglossal, vagus, glossopharyngeal, and spinal accessory nerves [7]. This type of damage can result in dysphagia, dysphonia, tongue deviation, and shoulder dysfunction, which will have a substantial influence on quality of life after surgery [8].The progression of the imaging modalities, especially the contrast-enhanced computed tomography angiography and Doppler ultrasonography, has enhanced the process of detecting variations of neovascularity during preoperative procedures [9]. The extensive mapping in anatomy enables the surgeon to foresee the possible complications, alter the course of surgery, and minimize the risks intraoperatively. Nevertheless, even with technological advancements, unforeseen anatomical differences still pose a problem to the operations [10]. Head and neck structures are highly functional and aesthetic in nature, and thus require proper surgical planning. The knowledge of normal anatomy and its typical variants is critical to reducing the number of complications and enhancing patient outcomes.

Study Objectives

To establish the frequency of neurovascular anatomical variants and to assess the effects on surgery planning, perioperative complications, duration of the operations, and the postoperative outcome of head and neck surgery.

Materials and Methods

Study Design & Setting

This Prospective Observational Study Conducted at Department Of Anatomy Rehman College Of Dentistry Peshawar From Jan 2025 To June 2025.It was aimed as a prospective observational study conducted in the Department of Head and Neck Surgery, a tertiary referral hospital, over 6 months.

Participants

100 patients who were on the waiting list for elective head and neck surgeries were recruited into the study. The sample included both male and female patients who were 18 years and older. The participants were subjected to thyroid, parotid, neck dissection, carotid, or maxillofacial surgery. Informed consent was obtained from all patients who participated in the study.

Sample Size Calculation

A sample size of 100 patients was estimated using the prevalence of 30 as a potential neurovascular anatomical variation, set at 95% confidence level, and the level of error was set at 8. It was calculated at a sufficient level to identify meaningful differences in intraoperative complication rates.

Inclusion Criteria

- Adults ≥18 years
- Candidates for elective head and neck surgery.
- Patients who have preoperative vascular imaging.
- Informed consent obtained

Exclusion Criteria

- Emergency surgical cases
- Extensive neck surgery in the past.
- Known coagulopathy
- Incomplete imaging data
- Refusal to participate

Management Strategy and Diagnostic.

Contrast-enhanced CT angiography and Doppler ultrasonography of vascular mapping of all patients were carried out. Noted anatomical differences were recorded before surgery and incorporated into a custom-made surgical design. Precautions in the operating room were also put in place to safeguard important vascular and neural structures.

Statistical Analysis

SPSS version 25 was used to analyze the data. Mean standard deviation was used to represent continuous variables, and percentages were used to represent categorical variables. Variables were compared using the independent t-test and chi-square test. The p-value that was deemed to be significant was set at 0.05.

RESULTS

Among the 100 patients enrolled, 58 were male and 42 were female, with a mean age of 46.8 ± 12.4 years. Neurovascular anatomical variations were identified in 37 patients. The most common variation involved external carotid artery branching patterns (21%), followed by venous drainage anomalies (10%) and atypical cranial nerve courses (6%). Patients with identified vascular variations demonstrated significantly higher intraoperative blood loss (520 ± 110 mL) compared to patients with normal anatomy (390 ± 95 mL), with statistical significance (p = 0.003). Operative duration was also longer in the variation group (145 ± 25 minutes versus 120 ± 20 minutes, p = 0.02). Transient cranial nerve deficits occurred in eight patients, primarily affecting the marginal mandibular branch of the facial nerve. No permanent major vascular injuries or mortality were recorded. Preoperative vascular imaging significantly reduced unexpected intraoperative findings (p = 0.01). Postoperative recovery was slightly prolonged in patients experiencing nerve-related complications; however, most deficits resolved within six weeks.

Intervention Outcome

The use of systematic preoperative neurovascular mapping enhanced the safety of intraoperative procedures, the occurrence of anatomical surprises, the rate of nerve injury, and surgical accuracy. The general postoperative outcomes were also very positive, indicating the consistent inclusion of vascular imaging in the surgical planning of complicated head and neck operations.

Table 1. Demographic Characteristics of the Study Population (n = 100)

Variable	Value
Total patients	100
Male	58 (58%)
Female	42 (42%)
Mean age (years)	46.8
Standard deviation (SD)	±12.4
Age range	18–72 years

Table 1 shows the baseline demographic characteristics of the study population. The majority were male (58%), with a mean age of 46.8 ± 12.4 years, indicating a middle-aged predominance among patients undergoing head and neck surgery.

Table 2. Distribution of Neurovascular Anatomical Variations (n = 100)

Type of Variation	Number of Patients	Percentage (%)
External carotid artery branching variation	21	21%
Venous drainage variation	10	10%
Cranial nerve course variation	6	6%
No variation detected	63	63%
Total with variations	**37**	**37%**

Table 2 summarizes the prevalence and types of neurovascular anatomical variations identified preoperatively. External carotid artery branching variations were the most common, occurring in 21% of patients.

Table 3. Intraoperative Parameters According to Anatomical Variation

Parameter	Variation Present (n=37)	No Variation (n=63)	p-value
Mean blood loss (mL)	520 ± 110	390 ± 95	0.003
Mean operative time (minutes)	145 ± 25	120 ± 20	0.02
Unexpected intraoperative findings	6 (16%)	2 (3%)	0.01

Table 3 compares intraoperative outcomes between patients with and without anatomical variations. Blood loss and operative time were significantly higher in patients with variations. Preoperative vascular mapping significantly reduced unexpected findings ($p < 0.05$ considered significant).

Table 4. Postoperative Complications (n = 100)

Complication	Number of Patients	Percentage (%)
Transient cranial nerve deficit	8	8%
Permanent nerve injury	0	0%
Major vascular injury	0	0%
Prolonged recovery (>7 days)	12	12%
No complications	80	80%

Table 4 demonstrates postoperative outcomes. Transient cranial nerve deficits were observed in 8% of patients, with no permanent nerve injuries or major vascular complications reported, indicating favorable overall surgical outcomes.

DISCUSSION

This finding demonstrates that clinically significant neurovascular differences are prevalent in elective patients undergoing head and neck surgery (37%) and are associated with increased intraoperative challenges, such as greater blood loss and extended procedure time, despite rigorous preoperative imaging [11]. Our results support the notion that anatomical risk is not merely an abstract concept; it directly impacts the complexity of surgeries and can lead to preventable morbidity when not anticipated beforehand. Similar to recent CTA-based morphologic studies, carotid system and branch variations are common and can be consistently identified using modern CT angiography protocols. Furthermore, this study also highlights significant differences in acoustic parameters, underscoring the importance of comprehensive preoperative evaluations. [12]. A large series of CTA have drawn attention to variability in the course and branch of the common carotid artery and its great branches, and that the variants are not infrequent and may change the risk profile of the procedure in a cervical approach [13]. The most common variants of the external carotid artery (ECA) branches in our group were the 21% branching. This is in line with imaging-based and morphometric reports that ECA branching variability is a recurrent clinical problem in the practice of surgeons and interventionalists [14]. Furthermore, recent studies suggesting more comprehensive aetiological classifications of particular branches of the ECA, i.e., variants of the origin of the ascending pharyngeal artery, support the importance of examining beyond the standard anatomy when it comes to the planning of skull base, pharyngeal, and oncologic resections [15]. Even though there are publications where there is a description of donor/ cadavers, recent analysis CTA-based studies are specifically suitable due to their reflection of the pre-operative setting and capability to be seamlessly incorporated into operative planning [16]. We have also reported considerably more blood loss in patients with vascular variants (p = 0.003) [17]. Although it is unfeasible to compare the studies directly due to the mix of procedures, the larger literature on head and neck surgery has agreed that deep vascular sources (e.g., branches of the maxillary artery and the pterygoid venous plexus) are the primary sources of challenging-to-control bleeding, especially with maxillofacial and orthognathic steps where anatomy is constrained [18]. Case-based evidence also shows that damage to venous plexuses could lead to devastating hemorrhage, further explaining why venous mapping and plexiform anatomy knowledge are important as arterial anatomy becomes [19]. Our patients experienced transient deficits of the cranial nerves in 8 per cent, but marginal mandibular branch dysfunction prevailed, as parotidectomy outcomes study literature indicates that early facial nerve dysfunction is the most frequent complication, and the marginal mandibular branch is often implicated [20]. Recent studies in quality improvement and observation of benign parotid surgery also focus on the variability in rates of palsy and show that the surgical technique and attentive manipulations with nerves are also essential factors that affect the outcomes [21]. The interpretation that nerve risk is determined by anatomical vulnerability and dissection planes also takes place with the support of the complementary procedural innovations (modified approaches that protect the marginal mandibular branch) [22]. One of the key contributions of our work is that preoperative mapping minimized unexpected data during intraoperative processes (p = 0.01), which is in favor of an emerging trend of an imaging-guided surgery paradigm [23]. Similar protocols of head-neck CTA were also reported as having yielded useful craniometrical arterial measurements able to alter the operative plan and outcomes in challenging surgery [24]. Technically, the recent study indicates that the quality of head and neck vascular CTA is constantly getting better, and contrast load is lowered by optimizing bolus tracking and using dual-energy techniques, which can expand the safe usage to the more at-risk patients [25]. Moreover, fast developments in AI-based head and neck CTA processing, vessel segmentation, and automatic plaque/stenosis classification can also decrease the variability in interpretation, as well as accelerate preoperative decision-making, particularly in large centers [26]. In general, our findings are consistent with new evidence that anatomic variation is widespread, clinically relevant, and becoming detectable with more advanced imaging. Future study ought to stratify findings on the basis of the levels of procedure type and variation category and should determine to what extent standardized reporting templates (arterial + venous + nerve-risk zones) enhance reproducibility and reduce complications across a range of institutions [27,28].

Limitations

There are several limitations associated with this study. It was done in one tertiary center, and the sample size is quite small (100 patients); it might not be generalizable. The follow-up was relatively brief (three months), which restricted the ability to assess the long-term outcomes. Also, the heterogeneity of surgery could have contributed to the rate of intraoperative and postoperative complications.

Conclusion

In conclusion, a thorough preoperative neurovascular evaluation plays a vital role in enhancing surgical planning, reducing complications, and ensuring the overall safety of head and neck surgeries. The implementation of detailed vascular mapping significantly minimizes intraoperative surprises and optimises patient outcomes, particularly in complex cases. Therefore, incorporating routine neurovascular assessments should be standard practice in head and neck surgery to improve both procedural success and patient safety.

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Reference

1. Chaware P, Kumar V, Srivastava A, Raj S, Rathinam BAD. Neurovascular Structures at Risk During Surgical Access to Trigeminal Ganglion and Meckel's Cave - An Anatomical Study. Adv Biomed Res. 2023 Mar 21; 12:62. doi: 10.4103/abr.abr_261_20.
2. Jain Y, Shinde V, Babu M. A Computed Tomography (CT)-Based Observational Study of Anatomical Variations in the Sphenoid Sinus: Implications for Surgical Planning and Patient Outcomes. Cureus. 2024 Aug 7;16(8): e66410. doi: 10.7759/cureus.66410.
3. Global Burden of Cardiovascular Diseases and Risks 2023 Collaborators. Global, Regional, and National Burden of Cardiovascular Diseases and Risk Factors in 204 Countries and Territories, 1990-2023. J Am Coll Cardio. 2025 2;86(22):2167-2243. doi: 10.1016/j.jacc.2025.08.015.
4. Hofmann A, Wagner D, Romens PM. Ili sacral screw osteosynthesis - state of the art. Arch Ortho Trauma Surg. 2025 Jan 11;145(1):122. doi: 10.1007/s00402-024-05716-5. PMID: 39797924.
5. Hong GW, Wan J, Yoon SE, Wong S, Yi KH. Anatomical Consideration for Double Chin Thread Lifting. J Cosmit Dermatol. 2025 24(6): e70238. doi: 10.1111/jocd.70238.
6. von Arx T, Bornstein MM. The bifid mandibular canal in three-dimensional radiography: morphologic and quantitative characteristics. Swiss Dent J. 2021 11;131(1):10-28. doi: 10.61872/sdj-2021-01-01.
7. Romanos G, Mulham J, Morrow N, Farber AH, Mahdian M. Neurological Risks During Implant Placement in the Anterior Maxilla and Mandible: A Literature Review. J Oral Implanted. 2023 Aug 1;49(4):428-435. doi: 10.1563/aaid-joi-D-23-00041.
8. von Arx T, Bornstein MM. The bifid mandibular canal in three-dimensional radiography: morphologic and quantitative characteristics. Swiss Dent J. 2021 Jan 11;131(1):10-28. doi: 10.61872/sdj-2021-01-01.
9. McMahon J, Steele P, Kyzas P, Pollard C, Jhampani R, MacIver C, Subramaniam S, Devine J, Wales C, McCaul J. Operative tactics in floor of mouth and tongue cancer resection - the importance of imaging and planning. Br J Oral Maxillofacial Surg. 2021 Jan;59(1):5-15. doi: 10.1016/j.bjoms.2020.08.118.
10. Soares J, Vieira R. Real-World Evidence of Langer's Axillary Arch: Bridging Anatomical Variations and Surgical Practice for Safer Axillary Procedures. Cureus. 2025;13;17(4): e82177. doi: 10.7759/cureus.82177.
11. Kaiser P, Schmidle G, Bode S, Seher U, Hones HR, Moring B, Perching E, Stoffer in H, Kon Schake M. Clinical-applied anatomy of the carpal tunnel regarding mini-invasive carpal tunnel release. Arch Ortho Trauma Surg. 2024 Nov;144(11):4753-4765. doi: 10.1007/s00402-024-05560-7.
12. Okon A, Landfall IC, Olewnik Ł. The Deep Head of the Masseter Muscle: A Classification-Based Anatomical and Surgical Framework. Biomedicines. 2025 Sep 8;13(9):2201. doi: 10.3390/biomedicines13092201.
13. Vera Larrea MR, Sant Ibáñez Vásquez R, Martínez Neira D. Prevalence of anatomical variants in preoperative computed tomography

imaging for surgical planning of the endonasal transsphenoidal corridor. Surg Neurol Int. 2025;30; 16:208. doi: 10.25259/SNI_294_2025.

14. Signoretti S, Signorelli F, Pesce A, Deltana A, Valsecchi M. Anterior Peritectomy vs. Retro sigmoid Approach-Surgical Anatomy and Navigation-Augmented Morphometric Analysis: A Comparative Study in Cadaveric Laboratory Setting. Brain Sci. 2025 Jan 23;15(2):104. doi: 10.3390/brainsci15020104.
15. Orland MD, Lin Y, Castillo Tafur JC, Deshpande A, Paladino L, Poulos CJ, Sood A, Kerns JM, Gonzalez MH. Hand size affects branching of the deep ulnar nerve and deep palmar arch. Surg Radial Anat. 2022 Dec;44(12):1501-1505. doi: 10.1007/s00276-022-03043-1.
16. Xu Y, Nunez MA, Mohyeldin A, Vigo V, Mao Y, Cohen-Gadol AA, Fernandez-Miranda JC. Microsurgical anatomy of the dorsal clinoidal space: implications for endoscopic endonasal Parisella surgery. J Neurosurgeon. 2022 Feb 4;137(5):1418-1430. doi: 10.3171/2021.12. JNS211974.
17. Xiao Y, Li P, Liu L, Song W, Wang R, Wang D, Xiang C, Xu C, Liu Y, Qian C, Liu H, Geng L, Zou Y. Anatomical Variations of the Trigeminal Arachnoid Membrane: Implications for Microvascular Decompression Surgery in Trigeminal Neuralgia. J Craniofacial Surg. 2025 jan 1;36(6):2117-2120. doi: 10.1097/SCS.0000000000011105.
18. Lakha at RS, Kataria T, Grover M, Kishor Lohar N, Badlani DK. Cochlear-Carotid Interval: Bridging Surgical Insights and Radiological Findings in Cadaveric Human Temporal Bones. Indian J Otolaryngology Head Neck Surg. 2024 Oct;76(5):4265-4269. doi: 10.1007/s12070-024-04832-3.
19. Triantafyllou G, Papadopoulos-Manoharis P, Arcudi's NA, Melonakos G, Samolis A, Vassie K, Fiske A, Pigou M. Morphological Spectrum of the Lateral Pterygoid Muscle: Radio anatomical Analysis, Systematic Review, and Meta-Analytic Synthesis. Medicina (Kaunas). 2025 Oct 1;61(10):1780. doi: 10.3390/medicina61101780.
20. Kacer I, Neli Chatzioglou G, Nas E, Coskun O, Garelli Ö. Surgical anatomy of the anterior choroidal artery: complex morphometry and morphological analysis of its origin and relations. Neurosurgeon Rev. 2025 jan 17;49(1):75. doi: 10.1007/s10143-025-04008-9.
21. Suresh N, Ch S, Patil K, Suresh N, Anil S. Prevalence and morphometric analysis of retromolar canals and foramina: a cone-beam computed tomography study. Oral Maxillofacial Surg. 2025 Mar 28;29(1):75. doi: 10.1007/s10006-025-01373-z.
22. Luzzi S, Triantafyllou G, Arcangeli N, Papadopoulos-Manoharis P, Gallio R, Tsakos's G, Olewnik Ł, Pigou M. Prevalence and Morphometry of Occipital Condylar Canals and Their Surgical Relevance. Oper Neurosurgeon. 2025 Dec 29. doi: 10.1227/ons.0000000000001885.
23. Triantafyllou G, Gatchopoulos I, Papadopoulos-Manoharis P, Arcangeli N, Demetriou F, Tsakos's G, Pigou M. Morphological variability of the jugular foramen: a comprehensive anatomical-imaging study emphasizing its compartmentalization. Neurosurgeon Rev. 2025 Jun 24;48(1):527. doi: 10.1007/s10143-025-03681-0.
24. Bestway KR. Morphology and dimensions of the nasopalatine canal in Palestinian patients assessed using cone beam computed tomography. Sci Rep. 2025;17;15(1):13248. doi: 10.1038/s41598-025-97392-7.
25. Rădoi PM, Rusu MC, Dincă D, Toader C. Combined rare anatomic variants: persistent primitive olfactory artery and azygos pericallosal artery. Surg Radial Anat. 2021 Aug;43(8):1305-1308. doi: 10.1007/s00276-021-02687-9.
26. Ahmed N, Komatsu F, Kato Y. Microvascular decompression of trigeminal nerve through endoscopic retro sigmoid keyhole approach: Anatomical considerations of the trigeminocerebellar artery, technical pearls, and pitfalls. Surg Neurol Int. 2025;4; 16:116. doi: 10.25259/SNI_6_2025.
27. Elizarrarás-Alonso B, Malabon-Hidalgo HO, García-Canoe E, Flores-Hernández JG, Menéndez-Anzac RA, Levered-Santana MA. Accessory Infraorbital Foramen: Prevalence in the Mexican Population by Tomographic Study. J Craniofacial Surg. 2025 01;36(5):1693-1696. doi: 10.1097/SCS.0000000000011117.
28. Hubbard OG, Miles JL, Duplechan DT, Shelton RJ, Ara H, Akoya AO. Concurrent Neural and Vascular Variations in the Gluteal Region Involving the Sciatic Nerve, Inferior Gluteal Nerve, and Gluteal Arteries: A Cadaveric Case Report. Cureus. 2025 feb 4;17(12): e98461. doi: 10.7759/cureus.98461.

