

Anatomical Variations in the Branching Patterns of Cervical Plexus in Plastinated Specimens

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Abstract— Background: The cervical plexus is formed by the anterior rami of the first four cervical spinal nerves (C1–C4) and gives important motor and cutaneous innervations to the head, neck and shoulder areas. The superficial cutaneous branches usually arise behind the posterior border of the sternocleidomastoid muscle at Erb's point (punctum nervosum). The varied branching dynamics and emergence patterns at Erb's point present major challenges in regional nerve block anesthesia, neck dissections, thyroidectomies, and anterior cervical spine surgeries. Compared to classical cadaveric studies which utilize wet, formalin-preserved tissue, plastinated specimens are non-toxic, structurally stable and accurate anatomical representations. The aim of the present study is to assess the anatomical variations of the emergence and branching patterns of the superficial cervical plexus as per Kim's classification in plastinated specimens in Iraqi medical college. **Methods:** For a period of 8 months, an observational cross-sectional study was done in the Department of Anatomy, College of Medicine, Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences. A total of 27 adult plastinated head and neck specimens (N = 27) were examined in a systematic manner. The superficial branches arising at or near Erb's point (lesser occipital, great auricular, transverse cervical and supraclavicular nerves) were classified according to Kim's anatomical classification into Types I to V according to their hierarchy of emergence. **Results:** Among the 27 plastinated specimens, the most common branching configuration was Type I (15 specimens, 55.56%). Type II was observed in 6 specimens (22.22%) followed by Type III in 3 specimens (11.11%) and Type IV in 2 specimens (7.41%). Type V was the least common, being found in only one specimen (3.70%). **Conclusion:** The study confirms the classic emergence pattern (Type I) as the primary configuration and variant branching dynamics at Erb's point are witnessed in more than 44% of cases within the evaluated Iraqi cohort. The structural fidelity of plastinated specimens makes it possible to preserve neuro-fascial relationships in a true manner without any spatial distortion caused by formalin. Anesthesiologists performing superficial cervical plexus blocks and head and neck surgeons should be aware of these topographic variations in detail to avoid iatrogenic nerve injury and surgical complications.

Keywords— Cervical plexus, Erb's point, Kim's classification, superficial cutaneous branches, Plastinated cadavers, Anatomical variation, Head and neck surgery.

I. INTRODUCTION

The cervical plexus (plexus cervicalis) is formed by the anterior primary rami of the first four cervical spinal nerves (C1–C4) with occasional contributions from C5 deep to the internal jugular vein and the sternocleidomastoid (SCM) muscle (Standring, 2021). The plexus gives off deep (mainly motor) branches to the infrahyoid muscles, the diaphragm (via the phrenic nerve), and the prevertebral muscles, and superficial (sensory/cutaneous) branches to the skin of the anterolateral neck, the superior chest, and the postauricular areas (Moore et al., 2020).

Cutaneous branches such as the lesser occipital nerve (LON, C2), great auricular nerve (GAN, C2–C3), transverse cervical nerve (TCN, C2–C3), and supraclavicular nerves (SCN, C3–C4) ascend or descend through the deep cervical fascia. Clinically, the site from which these four terminal cutaneous branches arise around the midpoint of the posterior border of the SCM muscle is known as Erb's point or the punctum nervosum (Kim et al., 2018; Tubbs et al., 2022).

The Erb's point is the main anatomic landmark for superficial and intermediate cervical plexus nerve blocks that are commonly used for carotid endarterectomies, fixation of clavicular fractures, thyroid surgery, and superficial neck procedures (Lee et al., 2020). However, the branching pattern, presence of common trunks and exact level of emergence in relation to Erb's point show great anatomical variability. Failure to recognize variations may result in patchy or

incomplete regional blockade, unexpected post-operative sensory deficits or an accidental neurovascular injury during neck dissections (Gupta et al., 2021).

Kim et al. (2018) suggested a classification system (Types I–V) to describe the superficial branching patterns of the cervical plexus according to the common trunk formations and the sequence of the emergence from the SCM border. The anatomical variability of the neck has been documented in the global literature; however, studies evaluating these patterns using plastinated cadaveric specimens in the Middle Eastern and Iraqi populations are scarce.

Plastination is a tissue preservation method where water and lipids are replaced by curable polymers to create dry, odorless, non-toxic, and dimensionally stable preparations that maintain accurate spatial relationships without the shrinkage and fascial distortion seen with traditional wet formalin preservation (von Hagens et al., 1987; Pasha et al., 2022). Thus, the present study was conducted to assess the variations in the formation and branching patterns of the cervical plexus at Erb's point in 27 plastinated adult specimens from Iraqi medical colleges for a period of 8 months.

II. MATERIAL AND METHODS

2.1 Study Design and Ethics Approval

This descriptive, observational cross-sectional study was performed over an 8-month period (from mid-2025 to early-2026). The study protocol was reviewed and approved by the

Ethics Committee of the College of Medicine, Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences, Najaf, Iraq. All specimens were prepared according to ethical standards for human cadaveric material in medical education and research.

2.2 Sample Characteristics

A total of 27 adult human head and neck plastinated specimens (N = 27) were studied. The main pool of samples was kept at the Department of Anatomy, College of Medicine, Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences, and some specimens were gathered from the participating anatomy departments in Iraqi medical colleges.

2.3 The Plastination Process

The specimens examined in this series were produced with standard cold-S10 silicone plastination:

1. Fixation: immersion in a 10% neutral buffered formalin solution for structural stabilization.
2. Dehydration: Repeated cold acetone baths (-20°C) to remove tissue fluids and lipids.
3. Forced impregnation: silicone resin (Biodur S10/S3) in vacuum, substitution of tissue acetone by silicone.
4. Curing: Exposure to Biodur S6 gas cross-linker to produce dry, flexible, anatomically correct specimens.

2.4 Anatomical Evaluation and Classification System

Every specimen was placed in the supine position and under standardized overhead lighting. With magnification, fine anatomical probes and micro-dissection tools were employed to trace the four cutaneous branches (LON, GAN, TCN, SCN) from their origin behind the SCM muscle to their distal subcutaneous courses.

The branching variations at Erb's point were classified by Kim's Classification (Kim et al., 2018):

- Type I (Independent Emergence): The four cutaneous branches (LON, GAN, TCN, SCN) all emerge independently from behind the posterior border of the SCM muscle without forming common shared trunks.
- Type II (Common Trunk for GAN & TCN): The great auricular nerve (GAN) and transverse cervical nerve (TCN) originate from a common trunk before splitting, while the LON and SCN split off independently.
- Type III (Common Trunk for LON & GAN): The lesser occipital nerve (LON) and great auricular nerve (GAN) arise from a common trunk, while TCN and SCN arise independently.
- Type IV (Common trunk for TCN & SCN): TCN and SCN have a common trunk before bifurcation, while LON and GAN occur independently.
- Type V (Triple or Complex Trunk): Three branches share a common trunk (e.g. LON + GAN + TCN or GAN + TCN + SCN) before they spread out cutaneously.

Data were reviewed by two senior human anatomists to ensure inter-observer consistency.

2.5 Data analysis

Data were tabulated using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA). The

prevalence of each Kim's type in the cohort was expressed using the descriptive statistics (counts [n] and percentages [%]).

III. RESULTS

All 27 adult plastinated head and neck specimens (N = 27) were successfully classified by Kim's classification. All five types (I-V) were found in the sample of the studied Iraqi population.

- Type I was the predominant configuration (as shown in figure 1), was identified in 15 specimens (55.56%).
- Type II was the second most common variation (as shown in figure 2), was observed in 6 specimens (22.22%).
- Type III (as shown in figure 3) was present in 3 specimens (11.11%).
- Type IV (as shown in figure 4) was found in 2 specimens (7.41%).
- Type V was the least frequent variation (as shown in figure 5), observed in 1 specimen (3.70%).

The distribution of Kim's classification types across the 27 plastinated specimens is summarized in Table 1.

TABLE 1: Frequency and distribution of cervical plexus branching patterns according to Kim's classification (N = 27).

Kim's Type	Emergence Description / Shared Trunks	Count (n)	Percentage (%)
Type I	Independent origin of all 4 branches (LON, GAN, TCN, SCN)	15	55.56%
Type II	Shared common trunk for GAN+TCN	6	22.22%
Type III	Shared common trunk for LON+GAN	3	11.11%
Type IV	Shared common trunk for TCN+SCN	2	7.41%
Type V	Complex/Triple shared trunk (e.g., GAN + TCN + SCN)	1	3.70%
Total	All Classification Types	27	100.00%

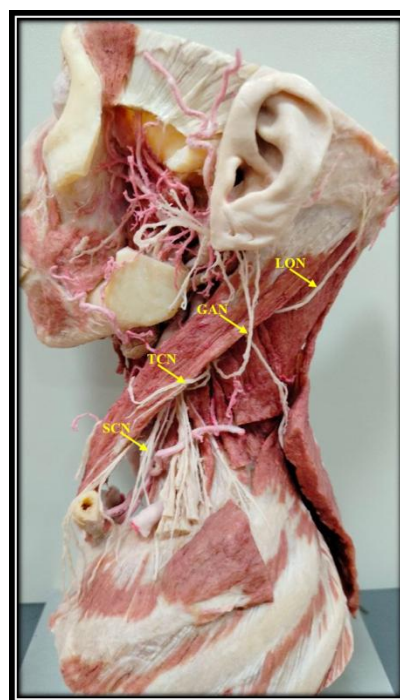


Fig. 1: Plastinated specimen of head & neck showing type I branching pattern of cervical plexus according to Kim's classification (Independent origin of all 4 branches (LON, GAN, TCN, SCN)).

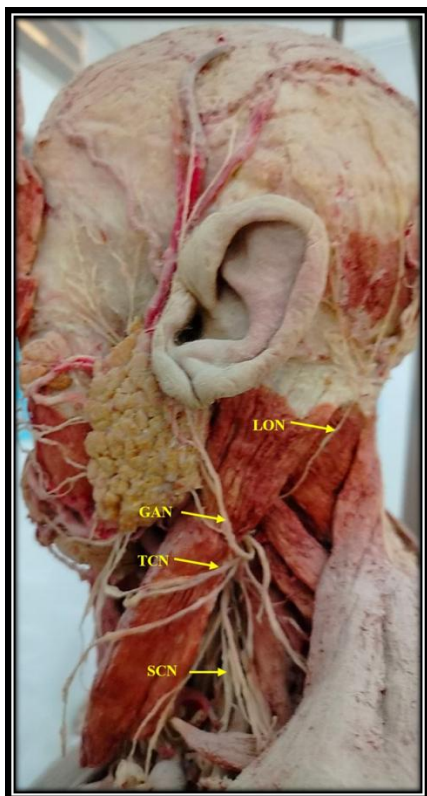


Fig. 2: Plastinated specimen of head & neck showing type II branching pattern of cervical plexus according to Kim's classification (Shared common trunk for GAN + TCN)

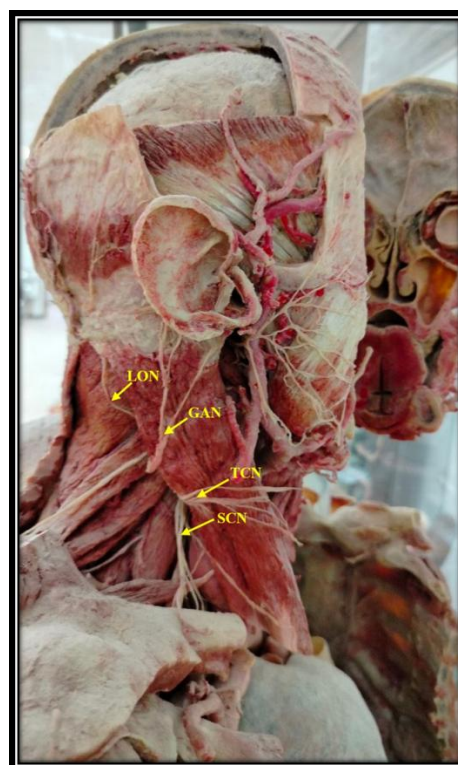


Fig. 4: Plastinated specimen of head & neck showing type IV branching pattern of cervical plexus according to Kim's classification (Shared common trunk for TCN + SCN)

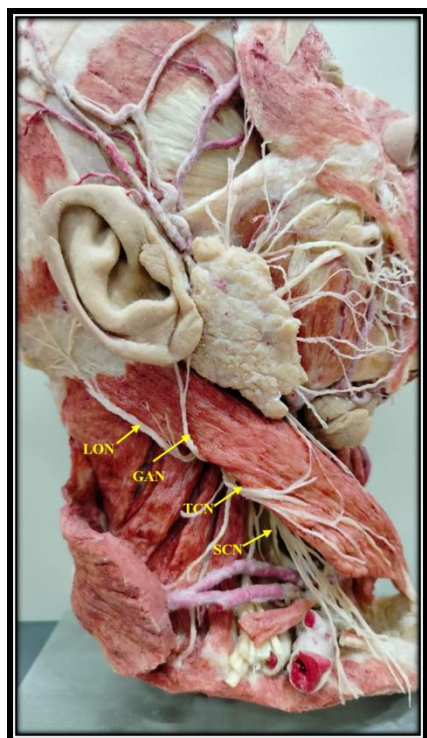


Fig. 3: Plastinated specimen of head & neck showing type III branching pattern of cervical plexus according to Kim's classification (Shared common trunk for LON + GAN)

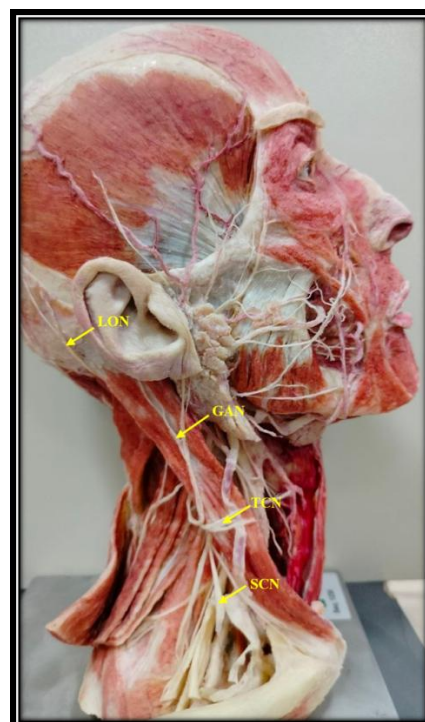


Fig. 5: Plastinated specimen of head & neck showing type V branching pattern of cervical plexus according to Kim's classification (Complex/Triple shared trunk (e.g., GAN + TCN + SCN))

IV. DISCUSSION

Interesting embryological variations in the formation and branching of the cervical plexus are present. In early embryogenesis (weeks 4-6), spinal nerve rami project migratory axons into the developing somitic mesoderm of head, neck, and upper limb buds. Variable levels of nerve origin and shared trunk configurations are seen when local neurotrophic signaling pathways or mechanical guidance cues are altered during fascial compartmentalization, which in turn changes trunk condensation (Moore et al., 2020).

In our study of 27 plastinated specimens from Iraqi medical college, the most common configuration was Type I (independent origin) with a frequency of 55.56% (n = 15). However, non-independent configurations (Types II–V combined) constituted 44.44% (n=12) of cases. This points out that common trunks at Erb's point are a common anatomical variation in this population cohort.

Comparison with Global Literature

The findings of this study are compared with relevant international cadaveric literature in Table 2.

TABLE 2: Comparative prevalence of cervical plexus branching variations across global anatomical studies.

Study	Sample size	Type I (%)	Type II (%)	Type III (%)	Type IV (%)	Type V (%)
Kim et al. (2018) (Korea)	50	52.0%	24.0%	12.0%	8.0%	4.0%
Gupta et al. (2021) (India)	40	57.5%	20.0%	10.0%	7.5%	5.0%
Present Study (2026) (Iraq)	27	55.56%	22.22%	11.11%	7.41%	3.70%

Our results are in line with the original results of Kim et al. (2018) and subsequent results of Gupta et al. (2021).

Type II (common trunk for GAN and TCN) is the most frequent variant trunk configuration among populations (22.22% in our study).

The close developmental proximity of the C2 and C3 nerve roots supplying both the GAN and TCN accounts for their frequent common origin before divergence near the posterior border of the SCM (Tubbs et al., 2022).

Clinical and Surgical Implications

1. Regional Anesthesia (Cervical Plexus Block) Intermediate and superficial cervical plexus blocks are achieved by infiltration of local anesthetic in a fan-like pattern along the posterior border of the SCM muscle centered at Erb's point (Lee et al., 2020). In Type II, III or IV configurations where branches course within a common epineural trunk, sub-epineural or perineural anesthetic deposition proximal to the bifurcation of the trunk produces rapid and effective block. In contrast, a missed variant trunk during blind anatomical landmark approaches may lead to incomplete sensory anesthesia of the anterior neck or inferior auricle.

2. Neck and Head Surgical Procedures: In radical or modified neck dissections, thyroidectomies, and anterior cervical

discectomy and fusion (ACDF) operations, surgeons preserve the GAN and TCN to reduce post-operative anesthesia or dysesthesia on the lower jaw, earlobe, and anterior chest wall (Strandberg, 2021). Identification of a common GAN-TCN trunk (Type II) is clinically important: traction or transection of this single shared trunk results in combined sensory loss in both the auricular and anterior cervical regions.

3. Plastination Utility: Plastinated specimens do not show the shrinkage, fascial blurring and tissue friability that occur with traditional formalin preservation. Silicone impregnation assists in maintaining thin neural branches, fascial penetrations and delicate epineural sheaths in their natural positions, permitting accurate anatomical documentation (Pasha et al., 2022).

Constraints

The major limitation of this study is the sample size (N = 27) which is representative of the technical complexity, long processing times and infrastructure needs for full-specimen silicone plastination in academic institutions. Future work should extend the specimen registry to include bilateral comparisons and correlate anatomy with high resolution ultrasound imaging in live clinical cohorts.

V. CONCLUSION

The present study is an anatomic study of the formation and branching pattern of the superficial cervical plexus at Erb's point using plastinated human specimens of different medical colleges in Iraq. The most frequent pattern is Type I (independent emergence) with 55.56%. Variant configurations with common trunks (Types II-V) occur in 44.44% of cases, the most frequent variant being Type II (shared GAN-TCN trunk) with 22.22%.

Accurate knowledge of these emergence patterns and shared trunk configurations is clinically useful to optimize regional anesthesia techniques and minimize iatrogenic nerve injury during head and neck surgery. Plastinated models are dimensionally stable and provide an accurate medium for detailed anatomical research.

Declarations & Disclosures Funding:

The authors received no funding or research grants for this study.

- Conflict of Interest: The authors declare no competing financial or personal interests.
- Ethical Approval: It was approved by Ethical Committee of the College of Medicine, Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences.
- Data Availability Statement: The datasets generated during the current study are available from the corresponding author on reasonable request.
- Author Contributions: The author team designed, dissected, measured, statistically analyzed, and wrote the manuscript.
- Type V was the least frequent variation and was found in 1 specimen (3.70%)

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