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ORIGINAL ARTICLE

Importance of the Accessory Nerve Course in the Neck Region for Surgical Procedures

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Abstract

This study aimed to contribute to scientific and technological advancements in surgical techniques by evaluating the anatomical course of the accessory nerve in the neck region through cadaver dissections. Bilateral neck dissections were performed on eight adult male cadavers fixed in formalin at the Anatomy Department of Dokuz Eylul University Faculty of Medicine. All measurements were taken based on marked reference points and horizontal planes. The accessory nerve crosses the internal jugular vein anteriorly at the lower edge of the posterior belly of the digastric muscle in 10 neck sides (62.5%). In two neck sides, we observed that a branch of the accessory nerve was separated through the sternocleidomastoid muscle before passing behind it (12.5%). The length of this nerve in the posterior neck region was 52.3 ± 9.88 mm, and was significantly greater on the left side ($p = 0.036$). The accessory nerve was tortuous unilaterally in two cadavers. In some cases, a branch of the accessory nerve was found proximally to the anterior border of the trapezius muscle, and a superficial lateral cervical lymph node was located very close to the accessory nerve. The study revealed significant individual variations in the course of the accessory nerve. To reduce the risk of accessory nerve damage and shoulder syndrome during surgical procedures, it is crucial to comprehend the position, course and distances of anatomical structures associated with the posterior belly of the digastric muscle, the sternocleidomastoid muscle and the trapezius muscle.

Keywords Accessory nerve · Neck dissection · Sternocleidomastoid muscle · Trapezius muscle

Introduction

The accessory nerve (AN) is the eleventh cranial nerve consisting of two parts, cranial and spinal divisions. The spinal division rises and joins with the cranial division [1, 2]. Along with the glossopharyngeal nerve and the vagus nerve, the AN exits the skull through the jugular foramen with the internal jugular vein. The spinal and cranial divisions of the AN then separate [2, 3]. The AN crosses the internal jugular vein proceeding posteriorly and inferiorly. It innervates the sternocleidomastoid muscle (SCM) and, after traversing the posterior neck region, reaches the lower part of the anterior border of the trapezius muscle (TM) and innervates this muscle [1]. The AN directly penetrates the SCM or gives a branch to the TM before penetrating the SCM. In both situations, various connections with the cervical spinal nerves may exist [4].

Lesions of the AN typically result from traumatic causes such as surgical dissection of the neck, accidents, birth traumas, and radiotherapy to the head and neck region [5–7]. Depending on the denervation of the TM, 'shoulder syndrome' may occur leading to deformities like limitation of shoulder movements, pain, loss of strength, dropped shoulder or wing scapula [4, 8].

The variations of the AN, its course in the neck, and its connections with other nerves likely account for the differences in functional loss when the same sections of the nerve are removed in different patients. Understanding the detailed anatomy of the relevant region is crucial in minimizing AN injury during head and neck surgery and improving the quality of life of patients [8, 9].

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In our study, we evaluated the AN in the neck region and its relationship with anatomical reference points including the neck surgical lymph node regions through dissection applications in cadavers. Our aim was to provide useful anatomical information to reduce the risk of AN injury in surgical interventions.

Methods

This study was conducted at the Department of Anatomy at Dokuz Eylul University School of Medicine. Ethical approval was obtained from the ethics committee of Dokuz Eylul University School of Medicine, and the study was conducted in accordance with the principles of the Helsinki Declaration. Bilateral neck dissections were performed on eight adult male cadavers that had been fixed in formalin. The ages of these cadavers were unknown. The neck regions had not been previously dissected, the clavicles were intact, and there were no surgical scars.

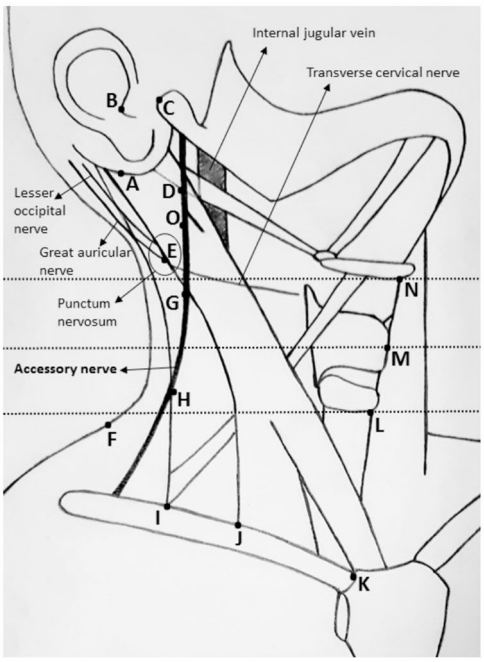


Fig. 1 Reference points and horizontal planes for parameters measured on cadavers. A: Mastoid process. B: Tragus. C: Head of mandible. D: Intersection of the AN at the lower edge of the posterior belly of the DGM. E: Point where the greater auricular nerve emerge on the posterior border of the SCM (punctum nervosum). F: Spinous process of the seventh cervical vertebra (C7).G: Point on the posterior border of the SCM where the AN emerges from behind the muscle. H: Point where the AN intersects the anterior border of the TM. I: Point where the anterior border of the TM attaches to the clavicle. J: Attachment point of the posterior border of the SCM to the clavicle.K: Sternoclavicular joint (sternal end of the clavicle). L: Horizontal plane passing through the lower border of the cricoid cartilage. M: Horizontal plane passing through the midpoint of the laryngeal prominence. N: Horizontal plane passing through the anterior midpoint of the hyoid bone. O: Entry point of the AN into the SCM

A measurement instrument was created to determine the parameters of horizontal planes. Two wooden rulers with 1 mm sensitivity were placed on a platform, parallel to each other and perpendicular to the ground. A movable arm was connected to these two rulers so that the arm was completely horizontal during up-and-down movements. Reference points at the dissection site were marked with colored pins. Figure 1 demonstrates the reference points and horizontal planes. All measurements were taken in the supine position with the head in a neutral anatomical position, using a digital caliper branded BTS, sensitive to 0.01 mm. Variations in the course of the AN were examined and photographs were taken with a Samsung branded digital camera.

The SPSS 21.0 (SPSS Inc., Chicago, IL, USA) program was used for statistical analysis. Descriptive data (minimum-maximum, mean, standard deviation and percentages) and frequency values of quantitative data were calculated for both the right and left sides and the total of both sides. When comparing the right and left sides, qualitative data were analyzed with the Wilcoxon signed rank test, and quantitative data were analyzed with the Pearson chi-square test. A p-value of <0.05 was considered statistically significant.

Results

Morphological Evaluation

The AN was located inferiorly and posteriorly from the lower edge of the posterior belly of the DGM towards the SCM. Starting from point D, the AN crossed the internal jugular vein anteriorly in 10 sides (62.5%); on the right side in two cadavers and bilaterally in four cadavers. In six sides, the AN was located laterally to the internal jugular vein without crossing it (37.5%), bilaterally in two cadavers and unilaterally on the left side in two cadavers.

In two cadavers unilaterally (on the left side), a branch of the AN penetrated the SCM, and the branch extending towards the TM passed behind the SCM (12.5%) (Fig. 2). In six cadavers, the AN fully penetrated the SCM bilaterally, with a frequency of 87.5%. It then emerged from the posterior border of the SCM to reach the posterior neck region [11, 14, 15]. In the posterior neck region, the AN was mostly straight after exiting the posterior border of the SCM, and it was tortuous unilaterally in two cadavers (on the right side in one cadaver and on the left side in the other). Also, it was observed that the AN received a nerve branch from the cervical plexus unilaterally in two cadavers (on the right side).

In three cadavers unilaterally (one on the left, the other two on the right), the AN was found to give a thin branch

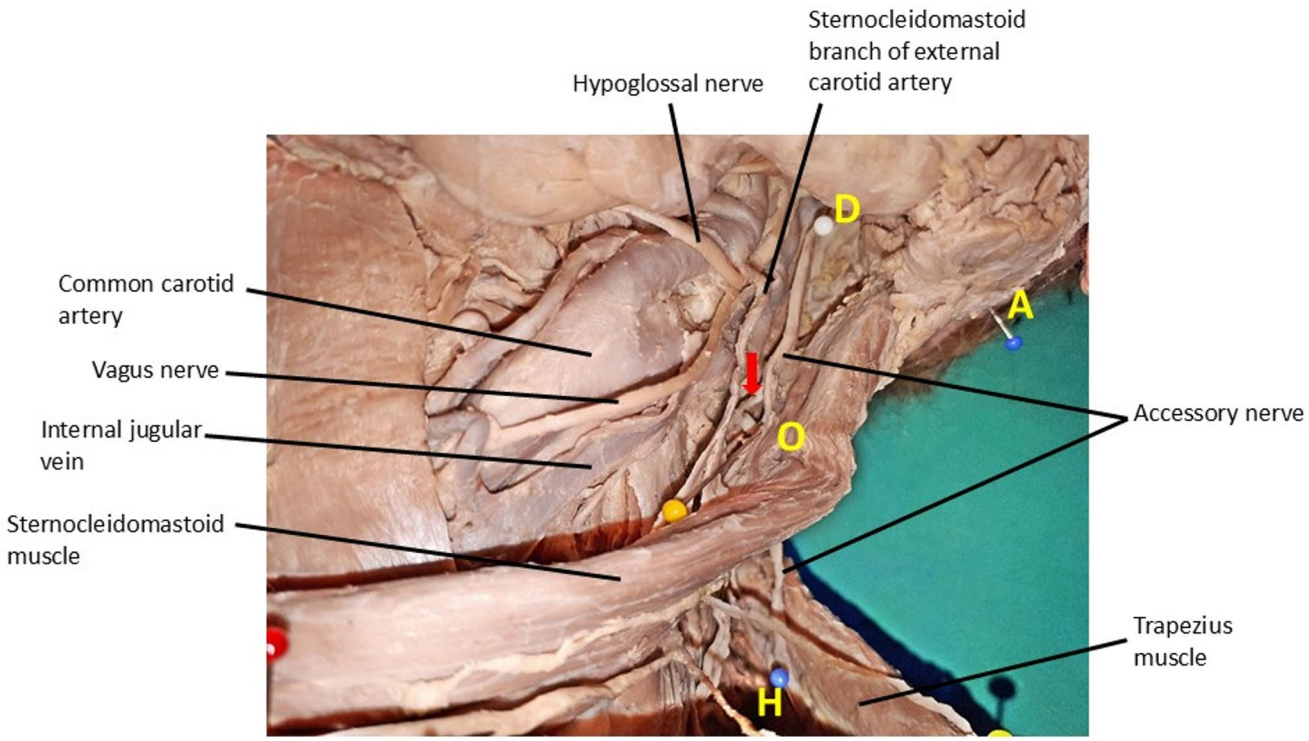


Fig. 2 The AN branches out to the SCM, then extends to the TM while passing behind the SCM (red arrow). A: Mastoid process. D: Intersection point of the AN at the lower edge of the posterior belly of the DGM. H: Point where the AN intersects the anterior border of the TM. O: Entry point of the AN into the SCM

that extended proximally to the anterior border of the TM. In one of these cadavers (on the right), the point where this branch originated was very close to where the AN emerged from the posterior border of the SCM. In four cadavers unilaterally, it was observed that a lymph node from the superficial lateral cervical lymph nodes was located near the point where the AN intersected the anterior edge of the TM in the posterior neck region (Fig. 3).

Morphometric Findings

This study measured the parameters that determine the location of the intersection point of the AN at the posterior belly of the DGM, referred to as point D. The distance from point G to point D was 45.52 ± 9.68 mm, the distance between points D and O was 29.19 ± 8.17 mm and the distance between point D and plane N was 37.62 ± 8.17 mm (Table 1).

The point where the AN emerges from the posterior edge of the SCM was evaluated in detail because it is an important reference point for surgery. The distance between points J and G (80.01 ± 13.49 mm) was greater than that between points A and G (62.95 ± 12.37 mm). The distance between point G and plane M was 23.04 ± 10.96 mm. There was no significance between the right and left sides (Table 2).

The parameters determining the location of the point where the AN intersects the anterior border of the TM (point H) are indicated in Table 3. The distance between points G and H (52.3 ± 9.88 mm) represented the length of the AN in the posterior neck region and was significantly greater on the left side ($p = 0.036$). The distance between point H and plane L was 24.87 ± 17.37 mm, and the distance between points I and H was 32.7 ± 13.48 mm.

The relative positions of the important reference structures for the course of the AN were indicated in Table 4. In 81.25% of the neck sides, point E was located below point G. There was no significance between the right and left sides.

Discussion

The present study demonstrated that the course of the AN may significantly vary between individuals. A higher rate of iatrogenic injury to the AN during neck surgery, require better analysis of the anatomy and variations in its course. Intraoperative studies are advantageous because the tissues are viable and allow for electrophysiological evaluation;

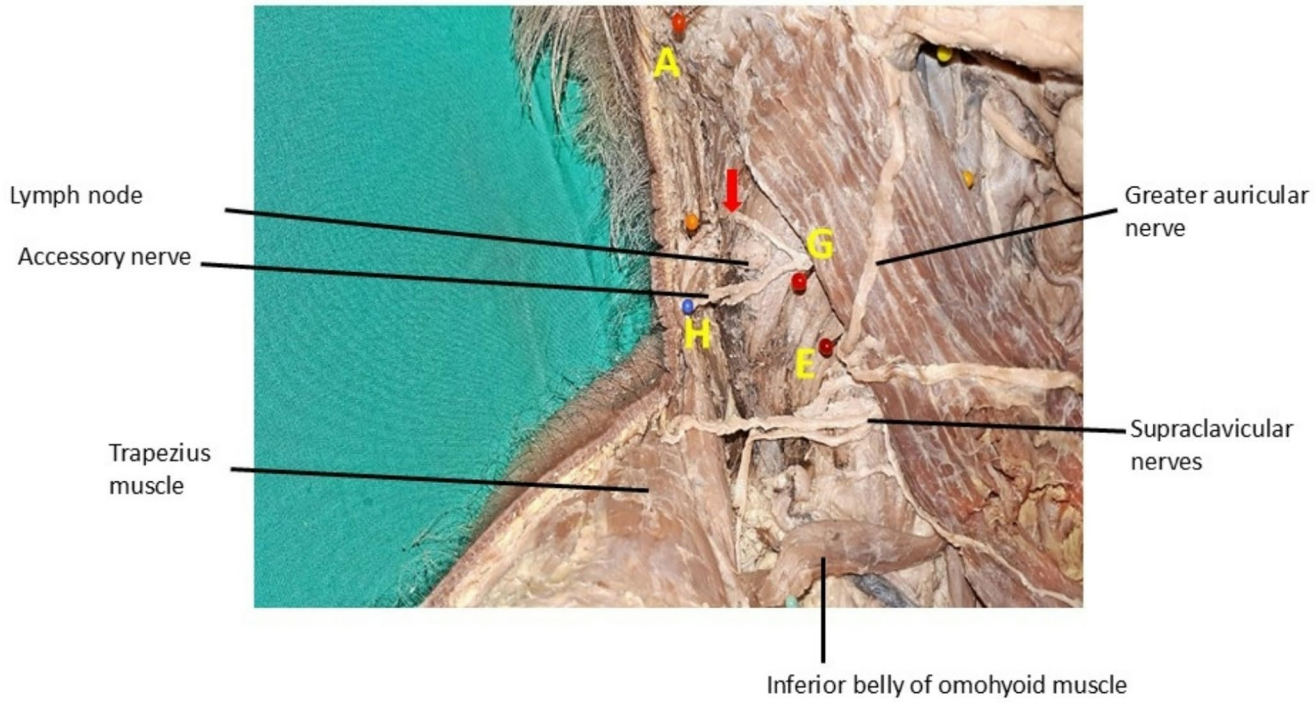


Fig. 3 A branch extending proximally to the anterior border of the TM (red arrow) and a lymph node located near the AN. A: Mastoid process. E: Punctum nervosum. G: Point on the posterior border of the SCM where the AN emerges from behind the muscle.H: Point where the AN intersects the anterior border of the TM

Table 1 The parameters that determine the location of point D

Parametres (mm)	RIGHT ($n=8$)	LEFT ($n=8$)	TOTAL ($n=16$)	p*
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	
Distance between points A and D	44.37 ± 10.45 (31.96–68.45)	45.28 ± 8.53 (35.93–61.18)	44.82 ± 9.23 (31.96–68.45)	0.575
Distance between points B and D	54.01 ± 6.68 (45.65–64.43)	57.52 ± 3.27 (53.87–63.51)	55.77 ± 5.39 (45.65–64.43)	0.123
Distance between points C and D	52.21 ± 7.37 (42.19–65.2)	54.99 ± 4.56 (50.09–65.31)	53.6 ± 6.09 (42.19–65.31)	0.208
Distance between points E and D	50.74 ± 6.41 (40.09–58.04)	44.8 ± 4.63 (36.27–49.67)	47.77 ± 6.21 (36.27–58.04)	0.05
Distance between points G and D	45.72 ± 5.01 (38.45–53.71)	45.32 ± 13.25 (26.01–63.39)	45.52 ± 9.68 (26.01–63.39)	0.779
Distance between points O and D	29.85 ± 9.58 (19.29–44.7)	28.53 ± 7.09 (19.87–36.83)	29.19 ± 8.17 (19.29–44.7)	0.674
Distance between point D and plane N	39.81 ± 8.65 (26.7-48.12)	35.43 ± 7.57 (25.09–46.75)	37.62 ± 8.17 (25.09–48.12)	0.069

* It was provided to compare the right and left sides

Min: Minimum, Max: Maximum, SD: Standard Deviation

A: Mastoid process

B: Tragus

C: Head of mandible

D: Intersection point of the AN at the lower edge of the posterior belly of the DGM

E: Punctum nervosum

G: Point on the posterior border of the SCM where the AN emerges from behind the muscle

N: Horizontal plane passing through the anterior midpoint of the hyoid bone

O: Entry point of the AN into the SCM

Table 2 The parameters that determine the location of point G

Parametres (mm)	Right ($n=8$)	Left ($n=8$)	Total ($n=16$)	p*
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	
Distance between points A and G	60.32 ± 5.92 (53.25–73.24)	65.58 ± 16.64 (38.28–87.62)	62.95 ± 12.37 (38.28–87.62)	0.327
Distance between points E and G	11.7 ± 5.82 (3.26–22.89)	17.02 ± 6.49 (8.14–27.63)	14.36 ± 6.56 (3.26–27.63)	0.401
Distance between points J and G	80.52 ± 16.77 (63.14-116.42)	79.5 ± 10.4 (61.78–98.27)	80.01 ± 13.49 (61.78-116.42)	0.674
Distance between points K and G	116.42 ± 18.08 (74.13-133.56)	117.02 ± 14.74 (97.92-131.82)	116.72 ± 15.94 (74.13-133.56)	0.889
Distance between point G and plane M	26.55 ± 6.33 (16.6-31.86)	19.52 ± 13.75 (5.17–40.26)	23.04 ± 10.96 (5.17–40.26)	0.208

* It was provided to compare the right and left sides

Min: Minimum, Max: Maximum, SD: Standard Deviation

A: Mastoid process

E: Punctum nervosum

G: The point on the posterior border of the SCM where the AN emerged from behind the muscle

K: Sternoclavicular joint

M: Horizontal plane passing through the midpoint of the laryngeal prominence

Table 3 The parameters that determine the location of point H

Parameters (mm)	Right ($n=8$)	Left ($n=8$)	Total ($n=16$)	p*
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	
Distance between points F and H	81.87 ± 20.35 (50.62-109.65)	79.66 ± 22.87 (45.45-108.51)	80.77 ± 20.94 (45.45-109.65)	0.889
Distance between points G and H	50.55 ± 10.78 (34.95–64.88)	54.04 ± 9.28 (42.22–65.27)	52.3 ± 9.88 (34.95–65.27)	**0.036**
Distance between points I and H	36.17 ± 14.08 (20.39–67.05)	29.24 ± 12.8 (11.43–49.68)	32.7 ± 13.48 (11.43–67.05)	0.575
Distance between points K and H	122.31 ± 12.27 (113-148.05)	124.71 ± 9.05 (110.56–141.3)	123.51 ± 10.49 (110.56-148.05)	0.327
Distance between point H and plane L	24.93 ± 19.31 (2.04–56.42)	24.82 ± 16.54 (7.82–56.23)	24.87 ± 17.37 (2.04–56.42)	0.674

* It was provided to compare the right and left sides

Min: Minimum, Max: Maximum, SD: Standard Deviation

F: Spinous process of the C7

G: Point on the posterior border of the SCM where the AN emerged from behind the muscle

H: Point where the AN intersects the anterior border of the TM

I: Point where the anterior border of the TM attached to the clavicle

J: Attachment point of the posterior border of the SCM to the clavicle

K: Sternoclavicular joint

L: Horizontal plane passing through the lower border of the cricoid cartilage

however, compared to cadaver studies, they are more limited in terms of anatomical data. Therefore, intraoperative studies on the anatomical course of the AN in the neck are complementary to cadaver studies [10–13].

In our study, the reliability of the measurements was increased by standardizing the measurements and evaluations with the measuring instrument we created to determine the horizontal planes. The horizontal planes passing through the anterior midpoint of the hyoid bone and the lower border of the cricoid cartilage, are located at the borders of the II. and V. surgical lymph node regions that the AN passed during its course in the neck [14]. Although, the mastoid process, the sternoclavicular joint and the spinous process of the C7 vertebra are palpable bony landmarks and useful as reference points. especially in the neutral anatomic position of the neck.

Table 4 The relative positions of the important reference structures for the course of the AN

Parameters	Right *n* (%)		Left *n* (%)		Total *n* (%)		*p**
	Above	Below	Above	Below	Above	Below	
Position of point E relative to plane N	3 (37.5%)	5 (62.5%)	2 (25%)	6 (75%)	5 (31.25%)	11 (68.75%)	0.59
Position of point E relative to point G	-	8 (100%)	3 (37.5%)	5 (62.5%)	3 (18.75%)	13 (81.25%)	0.055
Position of point G relative to plane N	6 (75%)	2 (25%)	4 (50%)	4 (50%)	10 (62.5%)	6 (37.5%)	0.302
Position of point G relative to plane M	8 (100%)	-	6 (75%)	2 (25%)	14 (87.5%)	2 (12.5%)	0.131
Position of point H relative to plane M	3 37.5(%)	5 (62.5%)	3 (37.5%)	5 (62.5%)	6 (37.5%)	10 (62.5%)	1
Position of point H relative to plane L	7 (87.5%)	1 (12.5%)	7 (87.5%)	1 (12.5%)	14 (87.5%)	2 (12.5%)	1

* The Pearson chi-square test was utilized

E: Punctum nervosum

G: Point on the posterior border of the SCM where the AN emerged from behind the muscle

H: Point where the AN intersects the anterior border of the TM

L: Horizontal plane passing through the lower border of the cricoid cartilage

M: Horizontal plane passing through the midpoint of the laryngeal prominence

N: Horizontal plane passing through the anterior midpoint of the hyoid bone

We emphasized and measured the parameters related to the intersection point of the AN at the lower edge of the posterior belly of the DGM, which is an important surgical reference point. In our study, this point was mostly located anterior to the internal jugular vein (62.5%). This is a factor that increases the likelihood of injury to the AN in operations where the internal jugular vein is excised [11, 14–17]. In cadaver studies this rate was stated as, 56% by Kierner et al. [18] and 80% by Saman et al. [19]. In intraoperative studies this rate was also stated as, 39.8% by Lee et al. [20], 95.7% by Taylor et al. [21] and 96% by Hinsley et al. [22]. The internal jugular vein could collapse in both cadaveric and intraoperative studies, which may have caused differences in the interpretation of the position of the AN.

In the literature, it was stated that the AN directly penetrated the SCM, emerged from the posterior border of the SCM and reached the posterior neck region [11, 14, 15]. In our study, the AN fully penetrated the SCM in 87.5% of the neck sides. In 12.5% of the neck sides, after giving a branch to the SCM, the AN passed behind this muscle through the TM. In cadaver studies, the AN passing posterior to the SCM after giving its branch to the muscle was reported as, 45.9% by Shiozaki et al. [23], 38.5% by Ohtawa et al. [4] and 20% by Dailiana et al. [24]; in intraoperative studies it was reported as, 45% by Lee et al. [20], 2% by Brennan et al. [12] and 22% by Lanisnik et al. [15].

The distance between the exit point of the AN on the posterior border of the SCM and the point where the AN intersected the anterior border of the TM was measured as 52.3 ± 9.88 (34.95–65.27) mm in our study. This measurement, which indicates the approximate length of the AN along the posterior neck region, holds significance in various operations conducted in this area, particularly in nerve graft procedures [5, 25]. Previous cadaver studies have reported this distance as 51 ± 11 mm by Placheta et al. [26], 35 (20–50) mm by Tubbs et al. [26] and 51 (48–54) mm by Popovski et al. [27].

It was noted in our study that the AN was unilaterally tortuous potentially allowing it to straighten and elogatei thereby reducing thr risk of damage from traction, as observed in certain intraoperative studies [27, 28].

Within the posterior neck region, we observed in two cadavers unilaterally on the right side that a nerve branch of the cervical plexus originating from the posterior border of the SCM joined the AN. This finding aligns with existing literature indicating that the AN receives a branch from the cervical plexus during its course in the neck [11, 12, 14, 15]. Some intraoperative studies have suggested that these nerve branches elicited a motor response with the AN in all three parts of the TM following electrophysiological examinations [11, 29].

Furthermore, in four cadavers in our study, a lymph node was examined near the AN in the posterior neck region. This proximity could potentially pose a risk of damage to the AN during lymph node biopsy procedures conducted in the posterior neck region [13].

Similar to findings in other studies [23, 24], we also observed that a branch of the AN extended proximally to the TM at the anterior border of the muscle.

In our study, the distance between the point where the AN intersected the anterior border of the TM and its attachment point to the clavicle on the anterior side was measured as 32.7 ± 13.48 mm. This distance differed from the cadaveric study by Symes et al. [28], where it was 40.8 ± 14.7 mm and from the intraoperative study by Hone et al. [30], where it was found to be 51.3 ± 14 mm.

The horizontal plane evaluations conducted with the instrument we developed are the original aspect of our study. The distance between the intersection point of the AN at the lower edge of the posterior belly of the DGM and the horizontal plane passing through the anterior midpoint of the hyoid bone was 37.62 ± 8.17 mm. The distance between the point where the AN emerged from behind the SCM and the horizontal plane passing through the midpoint of the laryngeal prominence was 23.04 ± 10.96 mm. The point where the AN intersects the anterior border of the TM and the horizontal plane passing through the lower border of the cricoid cartilage was 24.87 ± 17.37 mm.

Our study revealed significant individual variations in the course of the AN. Anatomical landmarks such as the lower edge of the posterior belly of the DGM, the posterior edge of the SCM and the anterior edge of the TM are crucial in preventing damage to the AN during surgical procedures, as they can be easily identified during neck dissections.

Conclusion

The detailed anatomy of the neck region associated with the AN is essential when planning head and neck surgery. This knowledge is crucial for minimizing injury to the AN and improving patients' quality of life. To reduce the risk of AN damage and shoulder syndrome during surgical interventions, it is essential to understand the position, course and distances of specific reference anatomical structures and horizontal planes.

Conducting studies with a larger number of cadavers of both male and female genders, will provide more detailed anatomical information about the course of the AN. In addition to cadaver studies, exploring the structure and functions of the AN electrophysiologically in surgical studies will contribute to a comprehensive evaluation of the nerve in the neck region.

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Declarations

Conflict of interest We have no commercial, financial or other relationships related to the subject of this article that might create a potential conflict of interest.

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