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Topographic and morphometric anatomy of the proximal part of the dorsal scapular nerve

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Abstract

The dorsal scapular nerve (DSN) entrapment neuropathy has recently been recognized as a common cause of circumscapular pain and cases of winged scapula. Course of the nerve is important because the middle scalene muscle is frequently accessed for surgical treatments. Studies in the literature have not focused on the morphometric relationship of the DSN with the scalene muscles and its relationship with the long thoracic nerve (LTN). The neck regions of 13 adult cadavers were dissected bilaterally. The relationship of DSN with scalene muscles and LTN was evaluated. Cervical spinal nerves involved in the formation of the DSN were identified. Three types of DSN were observed based on the cervical spinal nerves from which it originates, five types of DSN from its relationship with the scalene muscles, and two types of DSN from its relationship with the LTN. The distance from where the nerve pierces the scalene muscle to the mastoid process was found to be greater in DSNs originating from C4 and C5 (93.85 ± 4.11 mm, $p = 0.033$). In DSNs not connected with LTN, the distance from where the nerve pierces the scalene muscle to the superior trunk/C5 (12.74 ± 7.73 mm, $p = 0.008$) and the length of the nerve within the scalene muscle (14.94 ± 5.5 mm, $p = 0.029$) were found to be statistically significantly greater. The topographic and morphometric anatomy of the proximal part of the DSN is important, especially for scalene muscles-focused surgical treatments and interscalene nerve blocks. We believe our results may guide clinical approaches and surgery.

KEYWORDS
dorsal scapular nerve, long thoracic nerve, middle scalene muscle, scalene muscles

1 | INTRODUCTION

In standard anatomical books and atlases, the dorsal scapular nerve (DSN) is documented as a motor nerve originating from the anterior branch of the C5 spinal nerve (Gest, 2019; Gosling et al., 2017; Romanes, 1964; Snell, 2012; Standring, 2016; Tortora & Nielsen, 2010). In addition to C5, various sources have also reported involvement from the anterior branch of the C4 spinal nerve (Moore et al., 2018; Netter, 2014; Schuenke et al., 2014; Tubbs et al., 2016). However, anatomical studies in the literature have reported various variations on this subject (Ballesteros & Ramirez, 2007; Hanson & Auyong, 2013; Lee

et al., 1992; Nguyen et al., 2016; Shilal et al., 2015; Tubbs et al., 2005; Williams & Smith, 2020).

According to classical anatomy knowledge, the DSN pierces the middle scalene muscle after its formation and runs in the posteroinferior direction (Moore et al., 2018; Moses et al., 2013; Schuenke et al., 2014; Standring, 2016; Tubbs et al., 2015). However, in the literature, variations have also been reported in terms of its relationship with scalene muscles (Lee et al., 1992; Nguyen et al., 2016, 2017; Tetsu et al., 2018; Williams & Smith, 2020).

DSN entrapment neuropathy has recently been considered a common cause of circumscapular and interscapular pain, which are common clinical complaints with many etiologies. This neuropathy mostly occurs in the middle scalene muscle, which is the muscle pierced by the DSN (Chen et al., 1995; Sultan & Younis El-Tantawi, 2013). Although scapular winging is generally associated with the long thoracic nerve (LTN) and the spinal accessory nerve damage (Kuhn, 1999; Martin & Fish, 2008), cases of wing scapula due to DSN neuropathy have also been reported in the literature (Akgun et al., 2008; Argyriou et al., 2015; Sultan & Younis El-Tantawi, 2013). It has been stated that this entrapment neuropathy may easily be overlooked in the differential diagnosis because of the absence of DSN's sensory branches, the vagueness of symptoms, and the presence of many conditions with similar symptomology (Sultan & Younis El-Tantawi, 2013).

The middle scalene muscle is most commonly accessed for the surgical treatments of peripheral nerve sheath tumors, reconstructive brachial plexus surgery, and thoracic outlet syndrome. In addition, middle scalene muscle-focused surgical treatments are applied to relieve the symptoms of entrapment neuropathy. Surgery for a pathology around the muscle may compromise the DSN and the LTN located near the muscle (Puffer et al., 2019). Knowing the surgical anatomy of these nerves is important to maintain normal function of the scapula and prevent postoperative winged scapula (Crowe & Elhassan, 2016; Didesch & Tang, 2019; Puffer et al., 2019).

It has been stated in the studies that the DSN and the LTN may have a common branch (Ballesteros & Ramirez, 2007; Shilal et al., 2015; Williams & Smith, 2020). Considering the importance of these nerves in maintaining the scapulohumeral rhythm and the high frequency of entrapment, to understand the etiology of shoulder and interscapular region pain and scapular winging, the relationship of these nerves may be important (Sultan & Younis El-Tantawi, 2013; Williams & Smith, 2020).

It has been stated that the interscalene nerve blocks especially applied in surgeries related to the shoulder and cervical region for perioperative or chronic pain management, may cause damage to the DSN and the LTN (Kim et al., 2016; Saporito, 2013; Thomas et al., 2013). Also, it has been noted that thoracic outlet procedures, such as scalenectomy, used in the treatment of the syndrome pose a risk for the DSN and the LTN with a variable course (Williams & Smith, 2020).

Although there are various studies on the proximal part of the DSN in the literature, however, none of these are focused related to the morphometric relationship between the DSN and the scalene muscles. There are not enough studies on the relationship between the DSN and the LTN that may be clinically important. For this reason, we aimed to investigate the topographic and morphometric anatomy of the proximal part of the DSN.

2 | MATERIALS AND METHODS

The DSN was dissected and examined in 26 specimens from 13 adult cadavers (11 male/2 female) in the Istanbul Faculty of Medicine, Department of Anatomy. The body donors ranged in age from 48 to 73 years old, with a mean age of 62 years. The cadavers had no history of trauma or surgical procedures in the neck region. The authors state that every effort was made to follow all local and international ethical guidelines and laws that pertain to the use of human cadaveric donors in anatomical research (Iwanaga et al., 2022).

Each cadaver was placed in the supine position and to lift the skin in the neck area, the first incision was made on the midline, vertically from the gnathion point of the mandible to the midpoint of the jugular notch of sternum.

The second incision was made horizontally from the jugular notch of sternum along the upper edge of the clavicle and ending at the acromial end of the clavicle. The third incision was made horizontally, starting from the gnathion point and moving laterally along the lower edge of the mandible, passing through the angle of mandible (gonion point) and ending at the mastoid process.

Starting from the incision corners, the skin was lifted laterally and the superficial layer of cervical fascia, platysma, and the cutaneous branches of the cervical plexus were dissected. The external jugular vein and the superficial layer of deep cervical fascia were dissected, and the sternocleidomastoid muscle was revealed. Here, the spinal accessory nerve and the cutaneous branches of the cervical plexus were seen.

The sternocleidomastoid muscle was detached from its origin and reflected laterally. The superior trunk of the brachial plexus was identified between the anterior and middle scalene muscles, and the deep layer of deep cervical fascia overlying these muscles was removed. Thus, the brachial plexus was exposed, and the anterior ramus of spinal nerves from cervical plexus was dissected to reach the origin of the DSN.

After dissections, for morphological and morphometric evaluation:

- The anterior ramus of spinal nerves from cervical plexus, which are involved in the formation of the DSN.
- The relationship between the DSN and the scalene muscles.
- The length of the DSN within the scalene muscle(s).
- The relationship between the DSN and the LTN.
- The shortest distance between the point where the DSN pierces the scalene muscle(s) and the mastoid process.
- The shortest distance between the point where the DSN pierces the scalene muscle(s) and the superior trunk of the brachial plexus or the anterior branch of the C5 spinal nerve (Which of the two structures is closer to the point where the nerve pierces the muscle was preferred as the measurement point.) were examined (Figure 1A,B).

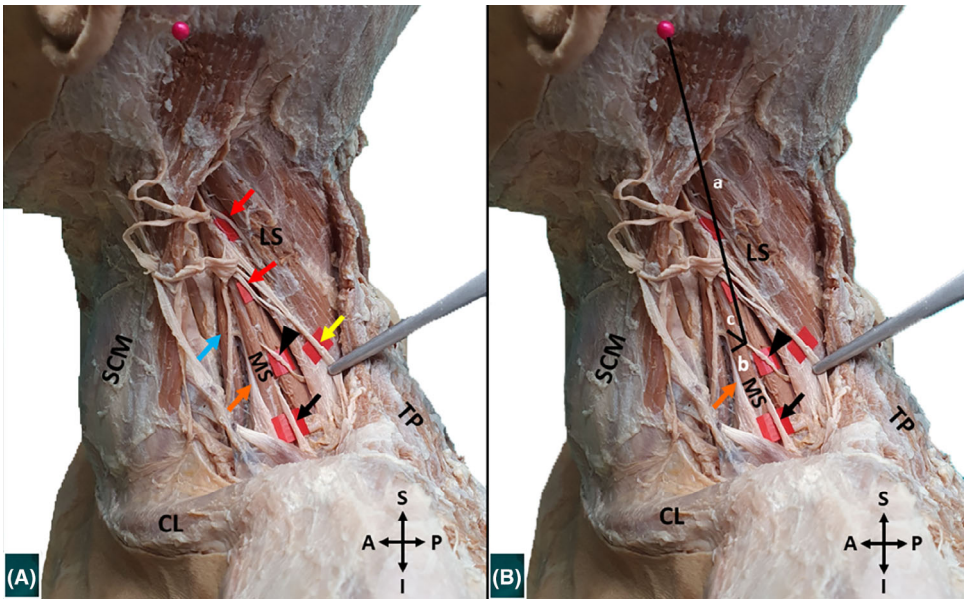

FIGURE 1 Reference points and distances for morphometric evaluation. (A) Red arrows: Anterior branches of C3 and C4 spinal nerves from top to bottom, Yellow arrow: Spinal accessory nerve, Orange arrow: Anterior branch of C5 spinal nerve, Black arrow: LTN, Black arrowhead: dorsal scapular nerve (DSN), Blue arrow: Anterior scalene muscle, MS: Middle scalene muscle, SCM: Sternocleidomastoid muscle, CL: Clavicle, LS: Levator scapulae muscle, TP: Trapezius muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. (B) a: The shortest distance between the point where the DSN pierces the scalene muscle(s) and the mastoid process (The pink pinhead indicates the position of the mastoid process.), b: The shortest distance between the point where the DSN pierces the scalene muscle(s) and the superior trunk of the brachial plexus or the anterior branch of the C5 spinal nerve (here, the anterior branch of the C5 spinal nerve was used as the measurement point because it is closer to the point where the DSN pierces the middle scalene muscle.) c: The length of the DSN within the scalene muscle(s).

All measurements were made bilaterally with a digital caliper (Mitutoyo Company, Kawasaki-shi, Kanagawa, Japan). The shortest distance was taken as reference when measuring the distances. The measurements were repeated three times by the same researcher, and the average of the measurements was recorded.

Statistical Package for the Social Sciences® software v23.0 for Windows (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis and interpretation of the obtained data. Whether the data showed normal distribution or not was evaluated with Kolmogorov–Smirnov and Shapiro–Wilk tests. Numerical data were expressed as mean and standard deviation, and categorical data as percentage (%). *T*-test was used for comparison between binary groups for parameters showing normal distribution. ANOVA test was used to compare three or more groups with normal distribution. Chi-square test, one of the parametric tests, was applied to continuous variables with normal distribution. The results were evaluated at 95% confidence interval and $p < 0.05$ significance level.

3 | RESULTS

3.1 | The anterior ramus of spinal nerves from cervical plexus that contribute to DSN formation

Three types of DSN were seen on 24 sides. 79.1% (19 sides) of the DSNs originated from the spinal nerve roots of C5, whereas 16.7% (4 sides) arose from both C4 and C5, and 4.2% (1 side) from C4.

3.2 | The relationship between the DSN and the scalene muscles

Five types of DSN were seen on 25 sides. Consistent with classical anatomy knowledge, 80% of the DSNs (20 sides) pierced the middle scalene muscle. 8% of the DSNs (2 sides) pierced the anterior scalene muscle, 4% of the DSNs (1 side) pierced both anterior and middle scalene muscles, and 4% of the DSNs (1 side) pierced the posterior scalene muscle. On 1 side (4%), the DSN coursed anterior to the middle scalene muscle without piercing any scalene muscle.

3.3 | The relationship between the DSN and the LTN

Two types of DSN were seen on 26 sides. 61.5% of the DSNs (16 sides) shared a common branch with LTN. 38.5% of the DSNs (10 sides) coursed separately without sharing a common branch with LTN.

In addition, the relationship between the DSN and the LTN was examined according to the DSN origin on 24 sides. 12 DSNs (75%) with a common branch with LTN originated from C5, while 4 DSNs (25%) originated from C4 and C5. 7 DSNs (87.5%) that did not have a common branch with LTN originated from C5, and 1 DSN (12.5%) originated from C4.

DSN types observed in our study are shown in Figure 2A–G.

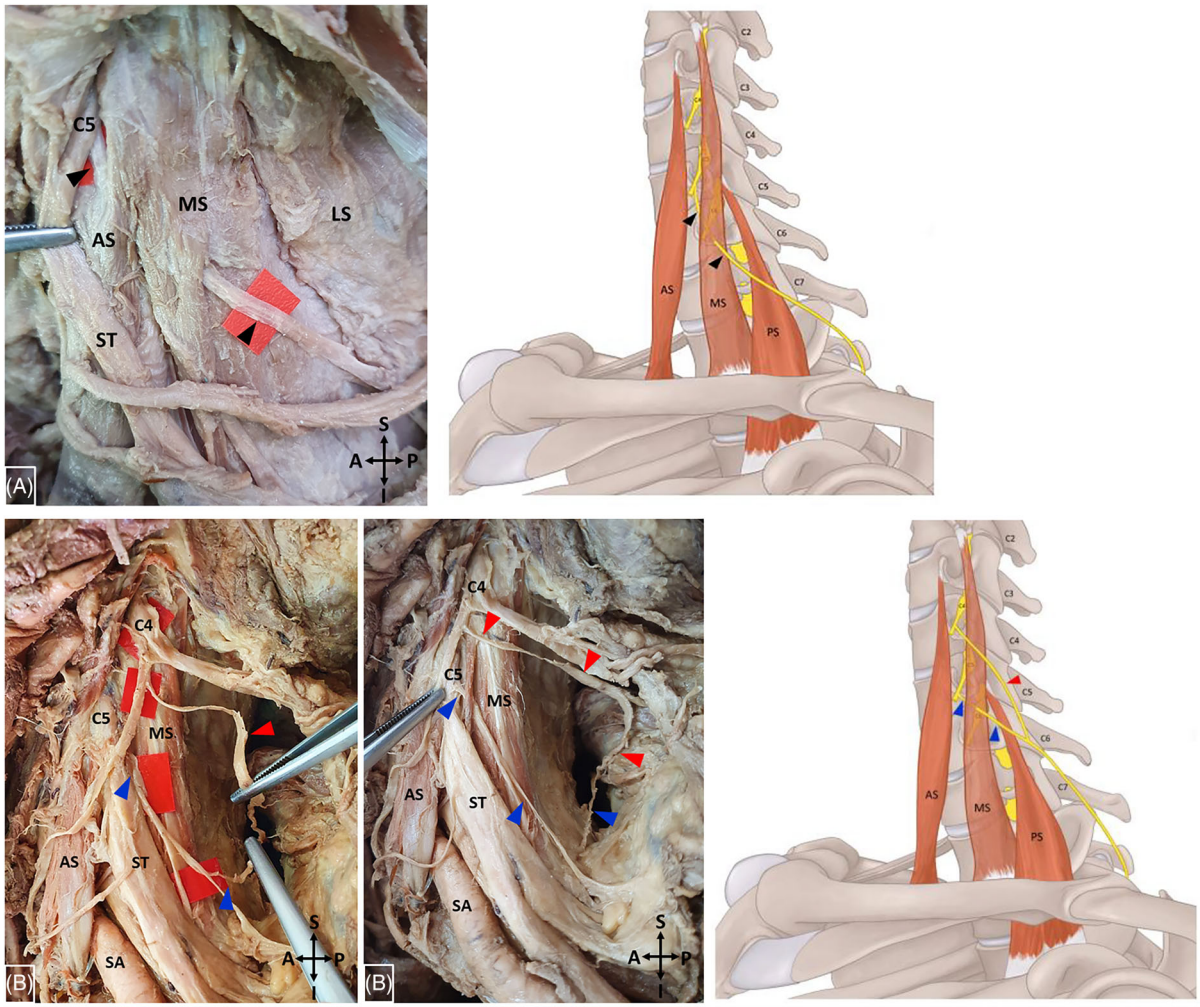

FIGURE 2 (A) This dorsal scapular nerve (DSN; left side) type was formed by the anterior branch of C5 and pierced the middle scalene muscle. Black arrowheads: DSN, ST: Superior trunk, AS: Anterior scalene muscle, MS: Middle scalene muscle, LS: Levator scapulae muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Black arrowheads: DSN, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle. (B) The two branches from the anterior branches of C4 and C5, indicated by the forceps, merged to form the DSN (left side), and the branch from C5 pierced the middle scalene muscle. Red arrowheads: Branch of DSN from C4, Blue arrowheads: Branch of DSN from C5, AS: Anterior scalene muscle, MS: Middle scalene muscle, SA: Subclavian artery, ST: Superior trunk, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Red arrowhead: Branch of DSN from C4, Blue arrowheads: Branch of DSN from C5, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle. (C) This DSN (right side) type was formed by the anterior branch of C4 and pierced the posterior scalene muscle (Pierced the muscle and came out from behind.). Black arrowheads: DSN, CL: Clavicle, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle, LS: Levator scapulae muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Black arrowheads: DSN, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle. (D) This DSN (right side) type was formed by the anterior branch of C5 and pierced the anterior scalene muscle. It also has a common branch with LTN. (It is also seen here that C5 is variably in front of the anterior scalene muscle.) Red arrowhead: DSN, *: Branch of LTN from C5, Black arrow: Branch of LTN from C6, AS: Anterior scalene muscle, MS: Middle scalene muscle, LS: Levator scapulae muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Red arrowhead: DSN, *: Branch of LTN from C5, Black arrow: Branch of LTN from C6, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle. (E) This DSN (left side) type was formed by the anterior branch of C5 and pierced both the anterior and middle scalene muscles. It also has a common branch with LTN. (It is also seen here that C5 is variably in front of the anterior scalene muscle.) Red arrowhead: DSN, *: Branch of LTN from C5, CL: Clavicle, AS: Anterior scalene muscle, MS: Middle scalene muscle, LS: Levator scapulae muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Red arrowhead: DSN, *: Branch of LTN from C5, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle. (F) This DSN (right side) type was formed by the anterior branch of C5 and traveled in front of the middle scalene muscle without piercing any scalene muscle. It also has a common branch with LTN. Black arrowhead: DSN, *: Branch of LTN from C5, Black arrow: Branch of LTN from C6, AS: Anterior scalene muscle, MS: Middle scalene muscle, LS: Levator scapulae muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Black arrowhead: DSN, *: Branch of LTN from C5, Black arrow: Branch of LTN from C6, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle. (G) This DSN (left side) type was formed by the anterior branch of C5 and pierced the middle scalene muscle. There was no common branch with LTN. Black arrowhead: DSN, Black arrow: Branch of LTN from C6, AS: Anterior scalene muscle, ST: Superior trunk, MS: Middle scalene muscle, LS: Levator scapulae muscle, A: Anterior, P: Posterior, S: Superior, I: Inferior. Schematic: Black arrowhead: DSN, Black arrow: Branch of LTN from C6, AS: Anterior scalene muscle, MS: Middle scalene muscle, PS: Posterior scalene muscle.

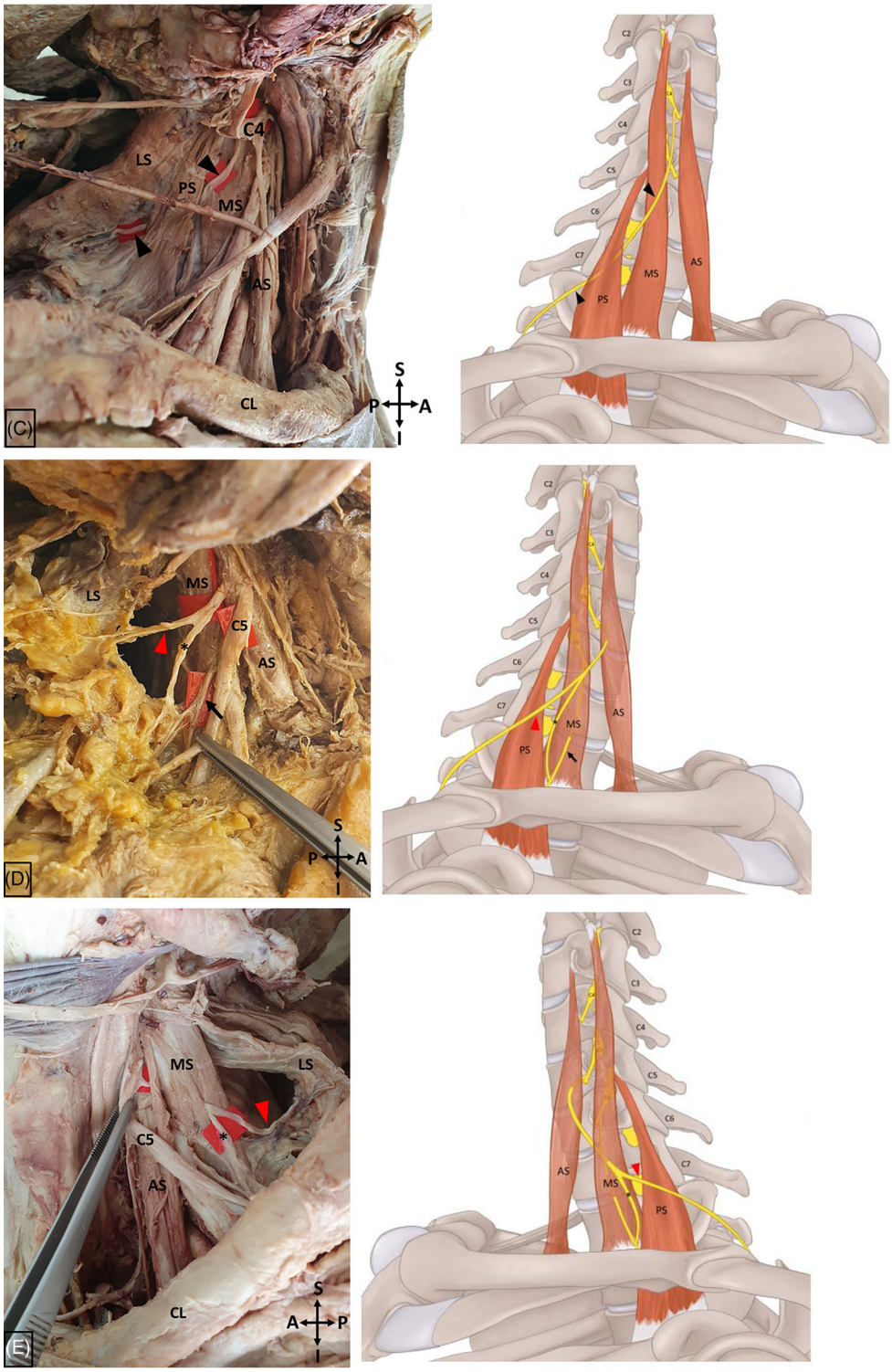

FIGURE 2 (Continued)

3.4 | The length of the DSN within the scalene muscle(s)

The length of the DSN within the scalene muscle(s) was measured on 23 sides. On the side where the nerve pierces both the anterior and middle scalene muscles, the total length in the two muscles was recorded. The mean value of this length in total was measured as 11.0 ± 6.47 mm. There was no significant difference in gender and side comparisons with statistical tests but when the DSN did not have a common branch with the LTN, this length was found to be greater with a statistically significant difference ($p = 0.029$).

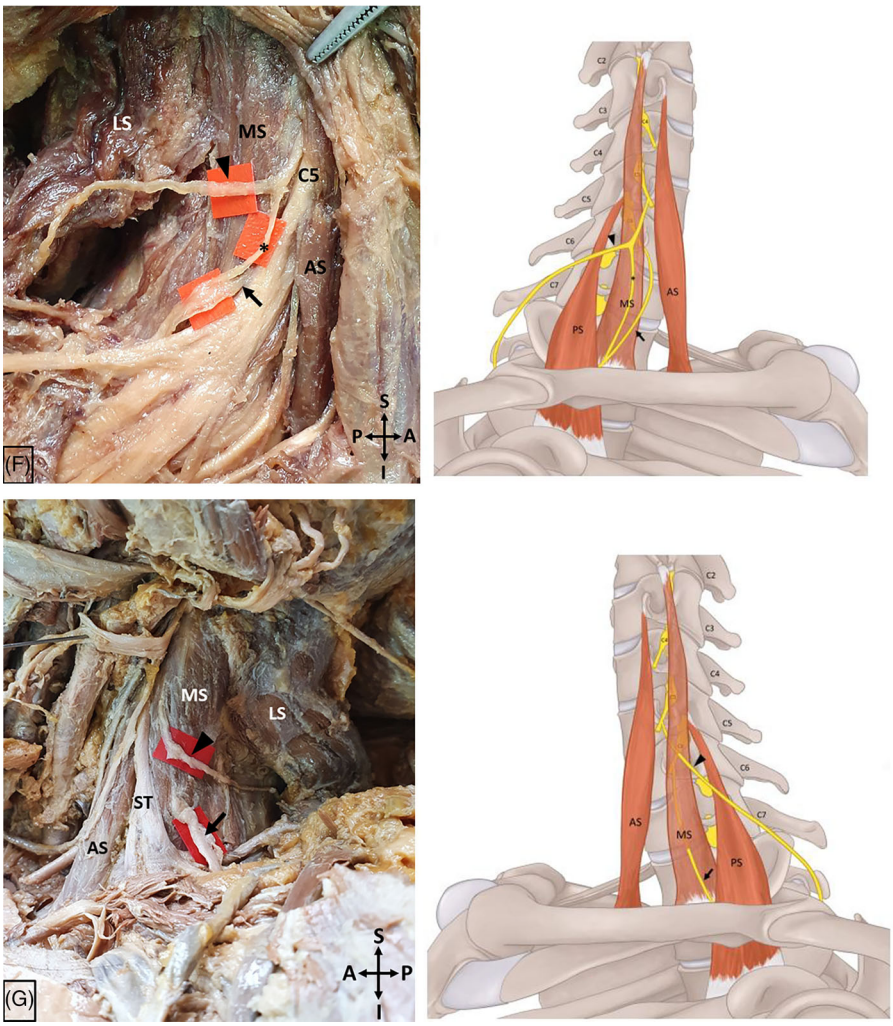

FIGURE 2 (Continued)

TABLE 1 Statistics of dorsal scapular nerve measurements.

Measurement	Mean ± *SD* (mm)					Range (mm) (total)
	Total	Female	Male	Right side	Left side	
Distance a	(N = 22) 86.84 ± 8.52	(N = 4) 86.57 ± 4.42	(N = 18) 86.9 ± 9.29	(N = 11) 88.53 ± 9.87	(N = 11) 85.15 ± 6.99	73.0–106.0
Distance b	(N = 24) 8.53 ± 5.73	(N = 4) 5.05 ± 1.79	(N = 20) 9.22 ± 6.02	(N = 12) 9.07 ± 7.66	(N = 12) 7.98 ± 3.07	0.0–28.9
Distance c	(N = 23) 11.0 ± 6.47	(N = 4) 6.37 ± 2.78	(N = 19) 11.97 ± 6.64	(N = 11) 10.65 ± 6.65	(N = 12) 11.32 ± 6.58	1.7–21.5

Note: *Distance a*: The distance between the point where the DSN pierces the scalene muscle(s) and the mastoid process. *Distance b*: The distance between the point where the DSN pierces the scalene muscle(s) and the superior trunk of the brachial plexus or the anterior branch of the C5. *Distance c*: The length of the DSN within the scalene muscle(s).
Abbreviations: *SD*, standard deviation; *N*, sample size.

3.5 | The distance between the point where the DSN pierces the scalene muscle(s) and the mastoid process

This measurement was performed on 22 sides. For the DSN running in front of the middle scalene muscle without piercing, between the point where the nerve exits between the anterior and middle scalene muscles and the mastoid process distance was measured. The mean value of this distance in total was measured as 86.84 ± 8.52 mm. There was no significant difference in gender and side comparisons with statistical tests but when the DSN originated from C4 to C5, this distance was found to be longer with a statistically significant difference ($p = 0.033$).

TABLE 2 Studies on dorsal scapular nerve origin.

Studies	Total *N*	Origin *N* and percentage					
		C5	C4 and C5	C4	C6	C5 and C6	Superior trunk
Lee et al. (1992)	145	110 75.8%	11 7.6%	-	11 7.6%	-	13 9%
Malessy et al. (1993)	4	-	4 100%	-	-	-	-
Fazan et al. (2003)	45	45 100%	-	-	-	-	-
Matejcik (2003)	100	96 96%	-	-	4 4%	-	-
Tubbs et al. (2005)	20	19 95%	-	-	-	1 5%	-
Ballesteros and Ramirez (2007)	56	27 48.3%	13 23.1%	16 28.6%	-	-	-
Olabu et al. (2008)	94	91 96.8%	3 3.2%	-	-	-	-
Sinha et al. (2012)	40	40 100%	-	-	-	-	-
Nguyen et al. (2016)	23	16 70%	-	5 22%	2 8%	-	-
Sharma et al. (2019)	50	47 94%	-	3 6%	-	-	-
Jack et al. (2020)	18	18 100%	-	-	-	-	-
Our study	24	19 79.1%	4 16.7%	1 4.2%	-	-	-

TABLE 3 Studies on relationship between dorsal scapular nerve and scalene muscles.

Studies	Total *N*	Piercing type				Non-piercing type	
		AS	MS	PS	AS + MS	Anterior to MS	Posterior to MS
Frank et al. (1997)	35	-	35 100%	-	-	-	-
Fazan et al. (2003)	45	-	33 73%	-	-	12* 27%	
Olabu et al. (2008)	94	-	76 80.4%	-	-	18 19.6%	-
Nguyen et al. (2016)	23	-	17 74%	-	-	3 13%	3 13%
Nguyen et al. (2017)	10	-	5 50%	-	-	4 40%	1 10%
Tetsu et al. (2018)	140	-	95 67.9%	-	-	45 32.1%	-
Williams and Smith (2020)	74	5 6.8%	31 41.9%	9 12.2%	-	?	16 21.6%
Our study	25	2 8%	20 80%	1 4%	1 4%	1 4%	-

Note: * and ?, No clear information; AS, anterior scalene muscle; MS, middle scalene muscle; PS, posterior scalene muscle.

3.6 | The distance between the point where the DSN pierces the scalene muscle(s) and the superior trunk of the brachial plexus or the anterior ramus of the C5

This measurement was performed on 24 sides. For the DSN running in front of the middle scalene muscle without piercing, between the point where the nerve exits between the anterior and middle scalene muscles and the anterior ramus of C5 spinal nerve distance was measured. The mean value of this distance in total was measured as 8.53 ± 5.73 mm. There was no significant difference in gender and side comparisons with statistical tests but when the DSN did not have a common branch with the LTN, this distance was found to be longer with a statistically significant difference ($p = 0.008$).

Statistics of DSN measurements (a–c) are summarized in Table 1.

4 | DISCUSSION

4.1 | The anterior ramus of spinal nerves from cervical plexus that contribute to DSN formation

Although the DSN is defined as a motor nerve originating from the anterior ramus of the C5 spinal nerve according to classical anatomy knowledge (Romanes, 1964; Snell, 2012; Standring, 2016), some sources also stated that there may be a C4 involvement (Moore et al., 2018; Netter, 2014; Schuenke et al., 2014; Tubbs et al., 2016). Other variations have also been noted in the literature. The findings of the studies in the literature on this subject and the findings of our study are given in Table 2.

Although they are not proportionally similar, due to the existence of three types of origin groups, the findings of our study are in line with the findings of Ballesteros and Ramirez's study (Ballesteros & Ramirez, 2007). The difference between the findings of other studies and our findings may have resulted from racial diversity, gender distribution, and the number of cadavers.

From a clinical point of view, studies are showing that the transfer of the DSN to the suprascapular nerve results in a positive result (Augustine et al., 2017; Goubier & Teboul, 2015). Additionally, in the study by Jack et al. (2020), the first branch to emerge from the anterior ramus of the C5 spinal nerve is usually the DSN and therefore, it was stated that knowledge about the proximal anatomy of the nerve may help in pathology localization and monitoring of clinical and neurophysiological recovery.

As a result, considering its clinical importance, in accordance with classical anatomy knowledge, although it is seen that the nerve mostly originates from C5, it should be taken into account that there may be variations.

4.2 | The relationship between the DSN and the scalene muscles

According to standard anatomy knowledge, the DSN pierces the middle scalene muscle (Moore et al., 2018; Moses et al., 2013; Schuenke et al., 2014; Standring, 2016; Tubbs et al., 2015). However, different variations have been recorded in the literature on this subject. The findings of the studies in the literature and the findings of our study are given in Table 3.

As a variation not mentioned in the literature, a type of DSN that pierces the anterior and middle scalene muscles together was found in our study. According to the studies, although the DSN mostly pierces the middle scalene muscle, it is important to note that the nerve may travel anterior and posterior to the middle scalene muscle. It has also been noted that contrary to classical anatomy knowledge, the nerve may pierce not only the middle scalene muscle; but also other scalene muscles.

From a clinical point of view, it has been stated that the nerve is usually trapped in the middle scalene muscle. Because of the absence of sensory branches, the vagueness of symptoms, and the presence of many conditions with similar symptomology, DSN entrapment is easily missed in the differential diagnoses (Sultan & Younis El-Tantawi, 2013).

One of the methods frequently used for the relief of symptoms of DSN neuropathy is nerve blocks (Saporito, 2013). It has been reported that during middle scalene muscle block, the DSN may be damaged if it travels anterior to the muscle, because it remains more superficial (Tetsu et al., 2018). It has also been stated that there is a risk of DSN injury in interscalene nerve blocks (Kim et al., 2016).

The DSN might not always pass through the middle scalene muscle, it may course anterior or posterior to the muscle, and it may also pierce anterior and posterior scalene muscles. In addition, the DSN may be compressed not only within the scalene muscles; but also between them and cause entrapment neuropathy. We think that these variations should be considered against the possible risk of DSN injury, especially for interventions in the posterior cervical triangle.

4.3 | The relationship between the DSN and the LTN

Although there is no standard defined relationship between the DSN and the LTN, it has been noted in studies that these two nerves may be connected.

Ballesteros and Ramirez (2007) reported that 17 (30.4%) of 56 DSN shared a common branch with LTN. In the case report study of Shilal et al. (2015), it was reported that unilateral DSN has an aberrant communicating branch with LTN. Williams and Smith's study (Williams & Smith, 2020) found that the DSN and the LTN share a common branch in 3 (4.05%) of 74 DSNs. In our study, a common branch was found between the DSN and the LTN in 16 (61.5%) of 26 DSNs, while no connection was observed in 10 (38.5%) sides.

From a clinical point of view, the fact that the middle scalene is a frequently accessed muscle is a risk factor for nearby the DSN and the LTN (Puffer et al., 2019).

It has been reported that the interscalene nerve blocks especially applied in surgeries related to the shoulder and cervical region, may

cause phrenic nerve damage when applied with an anterior approach (Kessler et al., 2008). Therefore, it is mostly applied with the posterior approach, but this approach also may cause damage to the DSN and the LTN (Feigl et al., 2020; Kim et al., 2016).

Anatomy knowledge about branching patterns, route variations, origins, and connection between these nerves can reduce the risk of iatrogenic damage. Considering the importance of these nerves in maintaining the scapulohumeral rhythm and the high frequency of entrapment, in order to understand the etiology of shoulder and interscapular region pain and scapular winging, the relationship of these nerves may be important (Sultan & Younis El-Tantawi, 2013; Williams & Smith, 2020).

The number of studies focusing on the relationship between the DSN and the LTN is limited in the literature. Therefore, we think that there is an inadequacy in revealing the connection between them, and more studies should be done on this subject.

4.4 | The length of the DSN within the scalene muscle(s)

There is no study on this subject in the literature. In our study, the mean value of this length was measured as 10.65 ± 6.65 mm on the right side, 11.32 ± 6.58 mm on the left side, 6.37 ± 2.78 mm in females, and 11.97 ± 6.64 mm in males.

In the study of Augustine et al. (2017), after the DSN was separated from the middle scalene muscle and its length was adjusted, it was transferred to the suprascapular nerve. In this operation, for the transfer phase and in surgeries related to the scalene muscles, in order to prevent any iatrogenic nerve damage that may occur, the length of the nerve in the muscle/muscles may be important. For this reason, we think that more studies are needed on this subject.

4.5 | The distance between the point where the DSN pierces the scalene muscle(s) and the mastoid process

There is no study on this subject in the literature. In our study, the mean value of this distance was measured as 88.53 ± 9.87 mm on the right side, 85.15 ± 6.99 mm on the left side, 86.57 ± 4.42 mm in females, and 86.9 ± 9.29 mm in males.

We think that the mastoid process, as a palpable structure may be important in surgeries related to the scalene muscles and anesthetic interventions.

4.6 | The distance between the point where the DSN pierces the scalene muscle(s) and the superior trunk of the brachial plexus or the anterior branch of the C5

There is no study on this subject in the literature. In our study, the mean value of this distance was measured as 9.07 ± 7.66 mm on the right side, 7.98 ± 3.07 mm on the left side, 5.05 ± 1.79 mm in females, and 9.22 ± 6.02 mm in males.

It has been reported that interscalene nerve blocks result in a high rate of hemidiaphragmatic palsy as a result of phrenic nerve block as an undesirable side effect (Urmey et al., 1991; Urmey & McDonald, 1992). As an alternative method to prevent this situation, superior trunk block has been defined by Burckett-St. Laurent et al. (2014). Also, the studies by Kim et al. (2019) and Kang et al. (2019) have stated that this method is as effective as interscalene block, and significantly reduce the rate of hemidiaphragmatic palsy.

We think that this distance we measured can facilitate both interscalene and superior trunk block with ultrasound guidance, and more studies are needed on this subject.

5 | CONCLUSIONS

Our study provides information about the origin of the DSN, its anatomical course, its connection with the LTN, and its morphometric relationship with the surrounding structures.

It should be noted that the only origin of the nerve may not be the C5 spinal nerve, and it may be located variably relative to the scalene muscles. In addition, there may be a highly anatomical connection between DSN and LTN, and more studies are needed on this subject due to its clinical importance.

The results we obtained from examining the topographic and morphometric anatomy of the proximal part of the DSN may guide especially for scalene muscles-focused surgical treatments and interscalene nerve blocks.

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