Investigation Of The Topographic Relations Regarding the Clinical Anatomy Of Levator Scapulae Muscle

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Abstract

Purpose: The levator scapula muscle is affected in cervical dystonia, myofascial pain syndrome, and it is a preferred muscle for tendon transfers and muscle flaps. There is no cadaveric study in the literature investigating the detailed anatomy of this clinically important muscle, including its topographic relationships and morphometric data. Therefore, our study aims to define the origins, insertions, innervations, topographic and morphological features of the muscle with cadaver dissections.

Methods: Those features of the muscle with the surrounding nerves were determined by bilateral dissections on 7 cadavers (4 males, 3 females) belonging to the Department of Anatomy of the University of Health Sciences, Hamidiye Faculty of Medicine. The morphometric measurements of the muscle were evaluated in the SPSS program with nonparametric statistical analysis and correlation methods.

Results: In the insertion region of the muscle, which starts with a 42.86% non-symmetrical attachment from different numbers of cervical vertebra, 66.66% m. found to be associated with serratus anterior. The origo width is 52.76 ± 7.89mm, with an average; insertion width 51.05 ± 5.25mm; axial length 124.64 ± 16.70mm; The width, thickness and distance of the widest part to the insertion were 36.57 ± 6.37, respectively; 9.14 ± 3.73; 54.97 ± 10.38 mm found.

Conclusion: We anticipate that our current findings will increase anatomical knowledge about the levator scapula and provide support for anatomy education and clinical approaches such as muscle transfer, myotomy, denervation, dry needling, flap applications.

Introduction

Levator scapula muscle (LSM) is found in the middle layer of back muscles. It also makes the base of the posterior cervical trigone [1, 2]. This muscle which has important topographically important neighborhoods in the neck region, is also of great clinical importance. Today, denervation, myotomy or injection of botulinum toxin at a rate of at least 40% for the treatment of the LSM, which is mostly affected by torticollis and laterocollis from cervical dystonia types, is common. [3-5]. In muscle transfer surgery performed for the treatment of trapezius muscle paralysis due to injury to the accessorius nerve, it is aimed to fulfill the function of the upper part of the trapezius muscle by using the levator scapula muscle [6, 7]. In addition, it is one of the preferred muscles for muscle transfer since the LSM is not damaged by 96% in plexus brachialis injuries [8, 9]. For the treatment of LSM, which may have an active trigger point in myofascial pain syndrome, invasive methods such as dry needling or non-invasive physiotherapy and rehabilitation treatment methods such as massage and stretching are used [10, 11]. In oral and oropharyngeal tumors, it is seen that the muscle used as a muscle flap and considered as a suitable muscle for the protection of the common carotid artery is ignored [12, 13].

The rich clinical importance of the LSM increases the importance of all anatomical information and topographic relationships related to the muscle. When the literature is examined, LSM originates from 1-4th cervical (C1-C4) vertebrates' posterior tubercules of transverse processes and it terminates at the medial angular angle of scapula and medial side of scapula. It is generally accepted that it is innervated by the cervical plexus and dorsal scapular nerve [1, 2]. However, it has been observed that it starts from different cervical vertebrates related to its origin and may attach to the mastoid process. Also with the additional insertional extensions related to its insertions, it can reach adjacent muscles such as rhomboids, serratus anterior, serratus posterior superior muscles, spinous processes of the vertebrates or nuchal ligament. The variations in which its attachments points have been identified [14-16]. While the innervation of the LSM with the dorsal scapular nerve is considered as the main source of innervation in basic anatomy books, it is seen that its innervation by the plexus cervicalis is not mentioned in various sources [1, 17, 18]. Frank et al. in his cadaver study, while cervical plexus innervation was rich, dorsal scapular nerve innervation was found in 11 of 35 cadavers [19]. While there is a study on the morphological features of the LSM on fetal cadavers, there is no study on adult cadavers where morphometric data is obtained and there are studies that take morphometric data in axial sections using imaging methods such as MRI and ultrasound [20-22].

The aim of this study is to contribute to the literature in line with the results obtained by researching the LSM's detailed anatomical information such as cadaver dissections, origin, insertion and innervation.

Materials And Methods

After the ethics committee approval was obtained from the Hamidiye Clinical Research Ethics Committee, dissections were performed on a total of 14 sides of 7 cadavers belonging to University of Health Sciences Hamidiye Faculty of Medicine Department of Anatomy. Since one of the cadavers was a head cadaver above the 1st thoracal (T1) vertebrate level, only origo information was obtained from this male head cadaver. All morphometric data were collected from the other 6 cadavers (3 males and 3 females). Posterior dissections were performed on the cadavers that were placed on the dissection table with the head hanging in the prone position. Starting from external occipital protuberence, the first incision line was created. Second incision line from the external occipital protuberence to the lateral auricle; A third incision line was created laterally by following the subcostal region from the T12 spinous process. A third incision line was created laterally by following the subcostal region from the spinous process of T12. Following these incision lines, first the skin and then the fascia superficialis were retracted laterally. Trapezius muscle was identified in the back. In the neck region, the skin and superficial fascia were retracted until the midline of the sternocleidomastoid muscle was visible. The borders of the posterior cervical trigone were defined by removing the fatty tissue in a way that would not damage the spinal branch of the accessory nerve and the cutaneous branches of the cervical plexus. The adipose tissue that emerged when the superficial investing fascia of the neck was cut was cleaned up to the deep investing fascia of the neck, and the dorsal scapular nerve, accessory nerve, cutaneous branches of the cervical plexus and the other cervical plexus branches that perforate the LSM were identified. In the later stages of the dissection, trapezius muscle was cut from its attachments to the spinous process from the inferior to the superior side. The trapezius muscle was retracted laterally by cutting the superior nuchal line as well. The origin, insertion and connections of the LSM are described. Roots of branches which were originating from cervical plexus were identified. The morphometric data given below regarding the LSM were measured with the help of digital caliper and goniometer:

1. Origo Width (OW): The distance between the transvers processes to which it was attached was measured in mm.
2. Insertion Width (IG): The distance between the top and bottom end of the total insertion was measured in mm.
3. Axial Length (AL): The distance between the IG midpoint and the OW midpoint was measured in mm.
4. Levator scapula index (LSI): It is obtained by dividing AL by cadaver length in cm and multiplying by 100 [23].
5. Width of the widest place (WWP): It was measured in mm perpendicular to the axial length.
6. Thickness of the widest place (TWP): The intramuscular part of the needle inserted in the midpoint of the WWP was measured in mm.
7. The distance of the widest place to the insertion distance (WWP-D) and to origo the one which distance (WWP-O): The distance between the midpoint of the WWP and the midpoint of the LR was noted in mm as LA-D. WWP-O was calculated by subtracting WWP-I from AL.
8. Positional angle (PA): The center of the goniometer was placed at the midpoint of the IG. When the fixed arm is vertical to the columna vertebralis; the active arm followed the midline of the muscle by bringing the head to maximum flexion and rotation. The value found was noted in degrees.
9. Visible edges of the muscle in the posterior cervical trigone; superior margin (SM): inferior margin (IM); medial margin (MM); measured in mm with the lateral margin (LM).

Statistical Analysis

Identification and analysis of all obtained data was performed using the Statistical Package for Social Sciences (SPSS) Version 20.0 (SPSS inc., Chicago, IL, USA) program. Variables were defined in terms of mean (Mean), standard deviation (ss), minimum (Min.) and maximum (Max .) values and frequency values (Q1= medial , Q2, Q3). Due to the less number of cadavers, Spearman Correlation Analysis, one of the nonparametric statistical analysis methods, was used as well as Mann-Whitney U test correlation methods. In the evaluation of the results, values of $p<0.05$ were considered statistically significant.

Results

When the origin of the LSM was evaluated on a total of 14 sides of 7 cadavers; C1-C3 vertebra (14.29%) on 2 sides; C1-C4 vertebra on 7 sides (50%), It was found that the transvers processes of the C1-C5 vertebra on 5 sides starts from the posterior tubercule (Figure 1).

In 42.86% of the cadavers, it was found that the origin points were not symmetrical on the right-left side. While the origins of unsymmetrical cadavers start from C1-C4 vertebrates on one side. On the other side it was starting from the C1-C5 vertebrates.

Vertebral numbers forming the origin points of the cadavers, on the right and left sides, are given in Figure 1. The heads of origins attached to the transvers processes of the C5 vertebrate were thinner and tendinous in shape compared to the heads of origins originating from other vertebrates.

In 6 of the cadavers, insertion findings were evaluated on a total of 12 sides. In all of the cadavers, the levator scapula muscle's superior angle and the part of the medial border of scapulae up to the spine of scapula were attached to both the costal face of scapula and the posterior face of scapula. In 4 of the cadavers, it was observed that the upper part of the serratus anterior attaching to the prima rib was also found to be bilaterally (66.66%) and to enter between the place where the muscle attaches to the inner and outer edges of the medial angle of the scapula. It was found that on 2 of the 8 sides connected in this way, the additional insertionel muscle extension serratus anterior, which separates from the LSM close to the insertion, proceeds from under the origin of the facies costalis scapulae (Fig. 3).

Two of the cadavers are bilateral with the origo heads starting from the cervical vertebrates grouped within themselves and continuing as two separate muscles and one of them (two muscles with C1-C2 vertebrate originated and C3-C5 vertebrate originated on the left) merge close to the insertion and end like a single muscle, it was found that the other (two muscles with C1-C3 originated and C4-C5 originated on the right and left) showed two different endings, one was deep and the other was more superficial, overlapping each other.

It was observed that the more superficial muscles showing separate insertion were mixed with the fibers of the rhomboideus minor. These muscles appeared as two separate muscles in the trigonum cervicale posterius. In all cadavers, lesser occipital nerve and spinal branch of accessory nerve in the upper half of the lateral edge of the visible surface of the levator scapula muscle in the posterior cervical trigone. It was detected that the greater auricular nerve and transversus colli were protruding close to the lower border of the lateral edge (Figure 4). It was found that the accessory nerve enters under the trapezius muscle near the cloer area of the lower border of LSM and courses on the surface of the LSM and rhomboid muscles at the level of the medial border of scapula.

The innervation information of the cadavers was evaluated on a total of 12 sides of 6 cadavers (Table 1). All evaluated cadavers had innervation of the LSM by the dorsal scapular nerve and pierced the muscle close to the insertion and passed posteriorly under the rhomboideus muscles. As given in Table 1, while there is no cervical plexus innervation on the right side in cadaver 6; It was observed that the dorsal scapular nerve was divided into 2 main branches, and one of these main branches was divided into 3 and entered the muscle from a total of 4 different places.

Table 1 : Nerve source and number of branches received by the LSM from the cervical plexus

source of innervation	cadaver 1		cadaver 2		Cadaver 3		Cadaver 4		cadaver 5		Cadaver 6	
	right	left	right	left	right	left	right	left	right	left	right	left
C3 ss	1	1	1	1	2	1	1	1	-	-	-	-
C4 ss	1	2*	1	1**	2*	1***	1	2*	1*	1*	-	1

SS: spinal nerve. *1 of 2 branches is divided into two and enters the muscle. **Enters the muscle by dividing into 3. ***Enters the muscle by dividing into 2.

The min., max., mean, sd and median values of the morphometric data obtained are given in Table 2. As a result of the comparison of the data according to the right and left sides, no significant difference was found but as a result of the comparison according to gender, a statistically significant difference was found between AL, TWP, WWP-O and IM. (Table 3).

A significant difference was found between the serratus anterior muscle and the insertion of the levator scapula muscle in PA and LSI.

When the data were compared according to the three different origin types we obtained in our study, a significant difference was found in the width of the origin ($p<0.05$). Correlation of data with each other is shown in Table 6 (rho <0.05).

Table 2 : Minimum, maximum, frequency, mean and standard deviation values of the data

Data	N	min.	max.	Median (Q1-Q3)	Mean ± SD
Size	6	148.80	176.50	161.95 (151.50-170.35)	161.65 ± 10.64
MV	14	40.79	64.89	52.18 (45.13-58.63)	52.76 ± 7.89
SPINDLE	12	41.62	58.45	50.63 (46.62-56.30)	51.05 ± 5.25
AL	12	99.07	155.84	124.06 (111.60-137.03)	124.64 ± 16.70
LSI	12	6.31	8.82	7.83 (7.18-8.18)	7.69 ± 0.76
WWP	12	27.53	46.15	36.01 (31.54-43.24)	36.57 ± 6.37
TWP	12	4.85	17.87	8.23 (6.74-10.72)	9.14 ± 3.73
WWP-I	12	34.08	67.81	53.13 (49.84-66.60)	54.97 ± 10.38
WWP-O	12	53.64	88.05	68.74 (57.61-81.34)	69.67 ± 11.98
SM	12	24.11	44.18	31.16 (29.04-37.10)	33.01 ± 6.10
HR	12	24.27	45.09	32.51 (26.36-41.09)	33.82 ± 7.57
MM	12	24.63	42.73	35.77 (28.37-37.60)	33.80 ± 5.48
LM	12	21.85	35.86	33.52 (32.42 -37.60)	32.39 ± 3.69
PA	12	53	81	78 (58.50-79)	71.42 ± 10.82

Table 3 : Comparison of data by gender

Data	Woman				Male				P*
	N	min.	Max .	Cover. ± SD	N	min.	Max .	Cover. ± SD	
Size	3	148.80	156.90	152.70 ± 4.05	3	167.00	176.50	170.60 ± 5.15	**0.04**
MV	6	43.84	58.02	50.57 ± 5.14	8	40.79	64.89	54.41 ± 9.47	0.36
SPINDLE	6	46.06	56.51	49.37 ± 3.57	6	41.62	58.45	51.95 ± 6.77	0.52
AL	6	99.07	131.13	113.48 ± 12.04	6	118.87	155.84	135.81 ± 13.02	**0.01**
LSI	6	6.31	8.61	7.44 ± 0.88	6	7.11	8.82	7.94 ± 0.58	0.26
WWP	6	27.53	42.52	34.20 ± 5.46	6	28.30	46.15	38.93 ± 6.79	0.15
TWP	6	4.85	7.51	6.40 ± 1.25	6	8.95	17.87	11.87 ± 3.34	**0.004**
WWP-I	6	34.08	67.81	51.11 ± 11.47	6	49.34	67.79	58.83 ± 8.37	0.37
WWP-O	6	53.64	68.89	62.37 ± 6.50	6	55.71	88.05	76.98 ±12.07	**0.02**
PA	6	57	79	71.33 ± 10.03	6	53	81	71.50 ± 12.53	0.46
SM	6	24.11	36.26	29.98 ± 4.08	6	29.34	4418	36.02 ± 6.58	0.10
HR	6	24.27	29.74	26.98 ± 2.02	6	35.28	45.09	40.66 ± 3.13	**0.004**
MM	6	24.63	37.74	30.60 ± 5.38	6	31.80	42.73	37.01 ± 3.56	0.05
LM	6	21.85	34.36	31.38 ± 4.72	6	29.19	35.86	33.40 ± 2.27	0.26

*Mann - Whitney Test, $p < 0.05$.

Table 4 : Correlation of data with each other

Data		MV	SPINDLE	WWP	TWP	PA	AL	LSI	WWP-I	WWP-O	SM	HR	MM	LM
Size	**rho**	**0.03***	0.69	0.72	**0.04***	0.42	**0.006****	0.22	0.56	**0.04***	0.16	**0.003****	**0.02***	0.18
	r	**0.60**	-0.12	0.11	**0.58**	0.25	**0.73**	0.38	0.18	**0.76**	0.42	**0.77**	**0.65**	0.41
MV	**rho**		0.88	0.21	**0.02***	0.67	0.13	0.36	0.15	0.39	0.36	0.16	0.06	0.52
	r		0.04	0.38	**0.63**	0.13	0.46	0.28	0.43	0.27	0.28	0.42	0.55	0.20
SPINDLE	**rho**			0.94	0.37	0.71	0.82	0.64	0.48	0.76	0.66	0.86	0.84	**0.03***
	r			0.02	0.28	0.11	-0.07	-0.14	-0.22	-0.09	-0.14	0.05	-0.06	**-0.60**
WWP	**rho**				**0.005***	0.64	0.47	0.79	0.07	0.91	0.24	0.15	0.98	0.10
	r				**0.75**	-0.14	0.23	0.08	0.53	-0.03	0.36	0.43	-0.01	0.49*
TWP	**rho**					0.65	**0.04***	0.33	0.12	0.15	0.21	**0.007****	0.21	0.28
	r					0.14	**0.59**	0.30	0.46	0.44	0.38	**0.72**	0.38	0.33
PA	**rho**						0.05	**0.02***	0.60	0.07	0.11	0.87	0.82	0.72
	r						0.56	**0.62**	0.16	0.52	-0.48	0.04	-0.07	-0.11
AL	**rho**							**0,000****	0.05	**0.001****	0.91	0.05	0.69	0.57
	r							**0.88**	0.57	**0.82**	0.03	0.55	0.12	0.18
LSI	**rho**								**0.02***	**0.01***	0.35	0.61	0.52	1.00
	r								**0.62**	**0.66**	-0.29	0.16	-0.20	0.00
WWP-I	**rho**									0.82	0.73	0.68	0.60	0.85
	r									0.07	-0.10	0.13	-0.16	0.06
WWP-O	**rho**										0.61	**0.03***	0.30	0.30
	r										0.16	**0.60**	0.32	0.32
SM	**rho**											**0.007****	0.12	0.20
	r											**0.73**	0.46	0.39
HR	**rho**												0.17	0.19
	r												0.42	0.39
MM	**rho**													0.24
	r													0.35

Spearman Correlation Analysis , *rho<0.05. **rho<0.01.

Discussion

Our study in which detailed anatomy information along with the morphological features of the LSM as a result of dissections of adult cadavers, is given, is a unique study in that there are no studies in the literature that make similar measurements and examinations. In our study, C1-C3; C1-C4; three different types of origin of origin were found starting from the transvers processes of the C1-C5 vertebrate.

However no variations similar to the origins of the mastoid process, trapezius, nuchal ligament, transvers processes of C6 and C7 defined together with the LSM in the literature [14, 15, 20, 24, 25]. In basic anatomy books and throughout the literature, origin is considered to start from C1-C4 vertebrates [1, 2, 26]). In a study on 60 cadavers, symmetrically C1-C2 (3.3%); C1-C3 (26.6); C1-C4 (66.6%); Onsets from C1-C5 (3,3) vertebrae are defined [15]. Among the cadavers we evaluated according to this study, the C1-C5 vertebral origin, which was found at a rate of 35.71%, was higher, C1-C3 vertebra origin, which we found with a rate of 14.29%, was found to be less common. However our findings support the general literature and the most common origo shapes were C1-C4 (50%) vertebral origin. In addition, in our study, it was found that the onset of origo was symmetrical with a rate of only 57.14%. It should be considered that the differences found between the right and the left without a significant difference in studies in which the cross-sectional area of the muscle is measured by panoramic ultrasound or MR imaging methods may be due to the difference in the heads of the origo, although it may be due to use, pathology or a compensatory mechanism [27, 28]The connection of the LSM with the serratus anterior which we found at the rate of 66.66% from the insertion point was found at a rate of 43.75% in a study performed with MR imaging method. [29].

In the same study, 5 of 9 people were found to be bilateral, while in our study m. serratus' connections were observed bilaterally in a total of 4 cadavers with anterior connections. In a cadaver study, a connection was found between the upper part of the serratus anterior and the LSM, supporting our findings. However, no ratio was given [30]. In the presence of serratus anterior connection m. The finding that the positional angle of the levator scapule approaches 90° reveals the necessity of changing the position given to the head for stretching exercises to be applied to the LSM. We think that this connection with the anterior may affect the functions of these two muscles which work as antagonists to each other, and that a problem in one of the muscles may affect the other. Similar to the variations we found in the LSM, where it continues as two muscles after the origin , Beger et al. In his study, a variation was found on one side, one with C1-C2 vertebra origin and the other with C5-C6 vertebra origin, continuing as two muscles and ending as a single insertion [20]. When compared with our study, although the origins differ, the same insertion was observed in one of the two cadavers in our study. In addition, in our study, these variations were found to be bilateral. Cervicale trigone of these variational muscles is among our findings that it looks two separate muscles in the posterius. No similar cases were found in the literature with imaging methods. However, it is a situation that can be encountered in imaging methods and should be considered. A detailed examination of the morphological features of the LSM, in which morphometric data such as cross-sectional area measurement, length measurement from the skin surface, length and insertion width on fetal cadavers were obtained was performed for the first time in our study [20-23].

Mean OD 52.76 ± 7.89 mm; IG 51.05 ± 5.25 mm; AL was found to be 124.64 ± 16.70 mm. In various studies, it is seen that LSI is calculated by taking the axial length of the muscle from the spinous process of the C2 vertebra to the angulus medialis scapulae [23, 31]. In related studies, similar to our study, the average LSI was found to be around 7.5. However, it was observed that the axial length measured in these studies was not given alone. In our study, the widest part was found to be closer to the insertion. This supports the increase in the area of the levator scapula musclee at C5-C7 levels in axial sections taken from various cervical levels [32]. Although unilateral cervical plexus inervation was not observed in a cadaver in this study, it was found that the cervical plexus was a rich source of innervation for levator scapula muscle. It was also found to be innervated by the dorsal scapular nerve in 12 side cadavers evaluated. Frank et al., in his study, only 11 of 35 cadavers had n. found to be innervated by the dorsalis scapuale [19]. In this study, similar to our study, the cervical plexus inervation source to the levator scapula muscle was rich; muscle was found to innervate approximately 2 nerves originating from the cervical plexus in each neck in 37 cadavers. The knowledge that trigger points in myofascial pain syndrome are related to the place where the nerve enters the muscle and that the trigger points defined in the LSM are also close to the insertion suggests that it may be related to the finding of muscle puncture of the dorsalis scapular nerve close to the insertion point [33, 34]. Due to the close topographical relationship of the LSM, accessory nerve, and cutaneous branches of the cervical plexus, supported by our study, surgical interventions such as tendon transfer to the muscle, myotomy or denervation, use as a muscle flap require additional attention in invasive interventions such as injection and dry needling.

Conclusion

We think that our original research study, in which the detailed anatomy of the LSM along with its morphological features and topographical relations to the peripheral nerves, will be a guide to basic anatomy education, clinical diagnosis and treatment process regarding the musculoskeletal system. We hope that our study will guide similar studies with more samples and studies to be conducted in the field of clinical anatomy.

Declarations

Author contributions All authors analyzed the cadavers data, analyzed the data regarding clinical

Aspects, wrote the first draft of the manuscript, read and approved the final manuscript.

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Declarations

Conflict of interests none declared

Ethics approval it was obtained from the Hamidiye Clinical Research Ethics Committee (number: 21/75)

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Figures

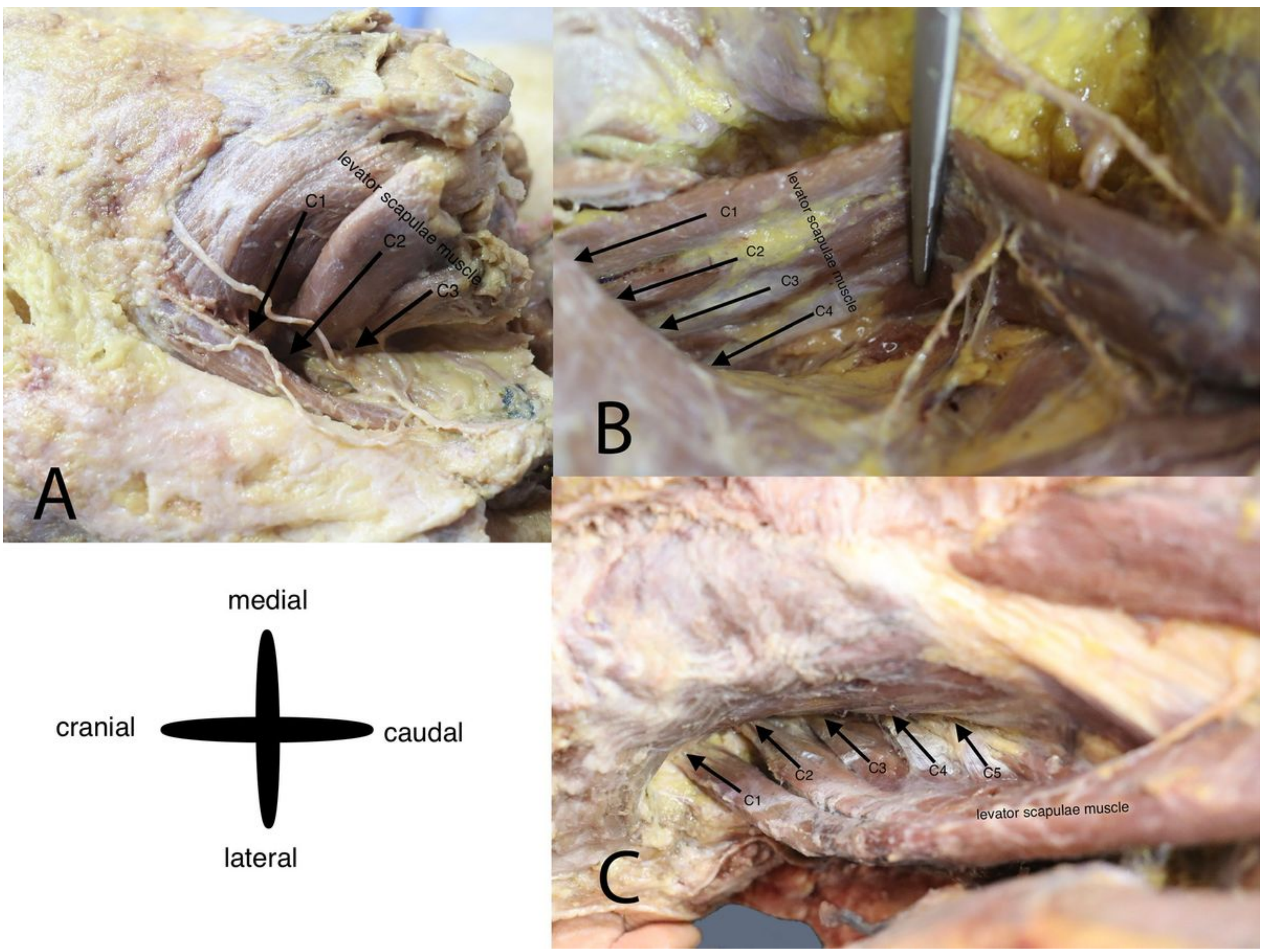

Figure 1

A: Examples of cadaver vertebrates with C1-C3 origins , B: cadaver specimen with C1-C4 origins, C: specimens with C1-C5 vertebrate origins

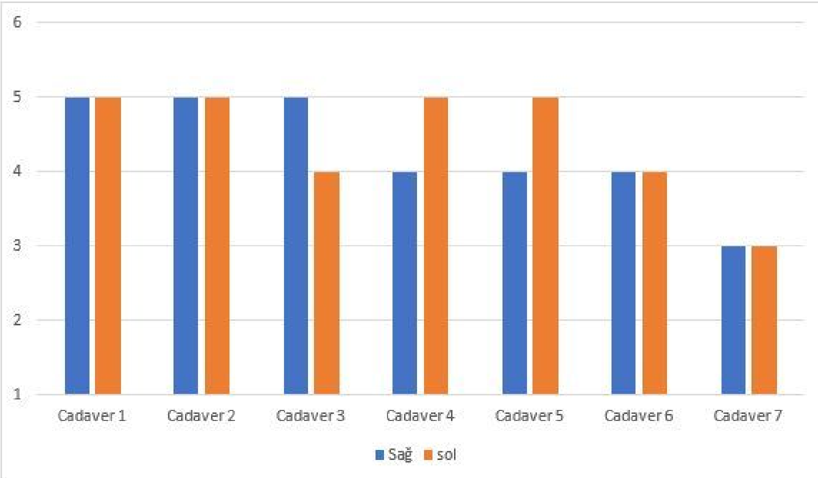

Figure 2

Cervical vertebrae where cadavers originate from right and left sides. (The vertical column corresponds to the cervical vertebra numbers)

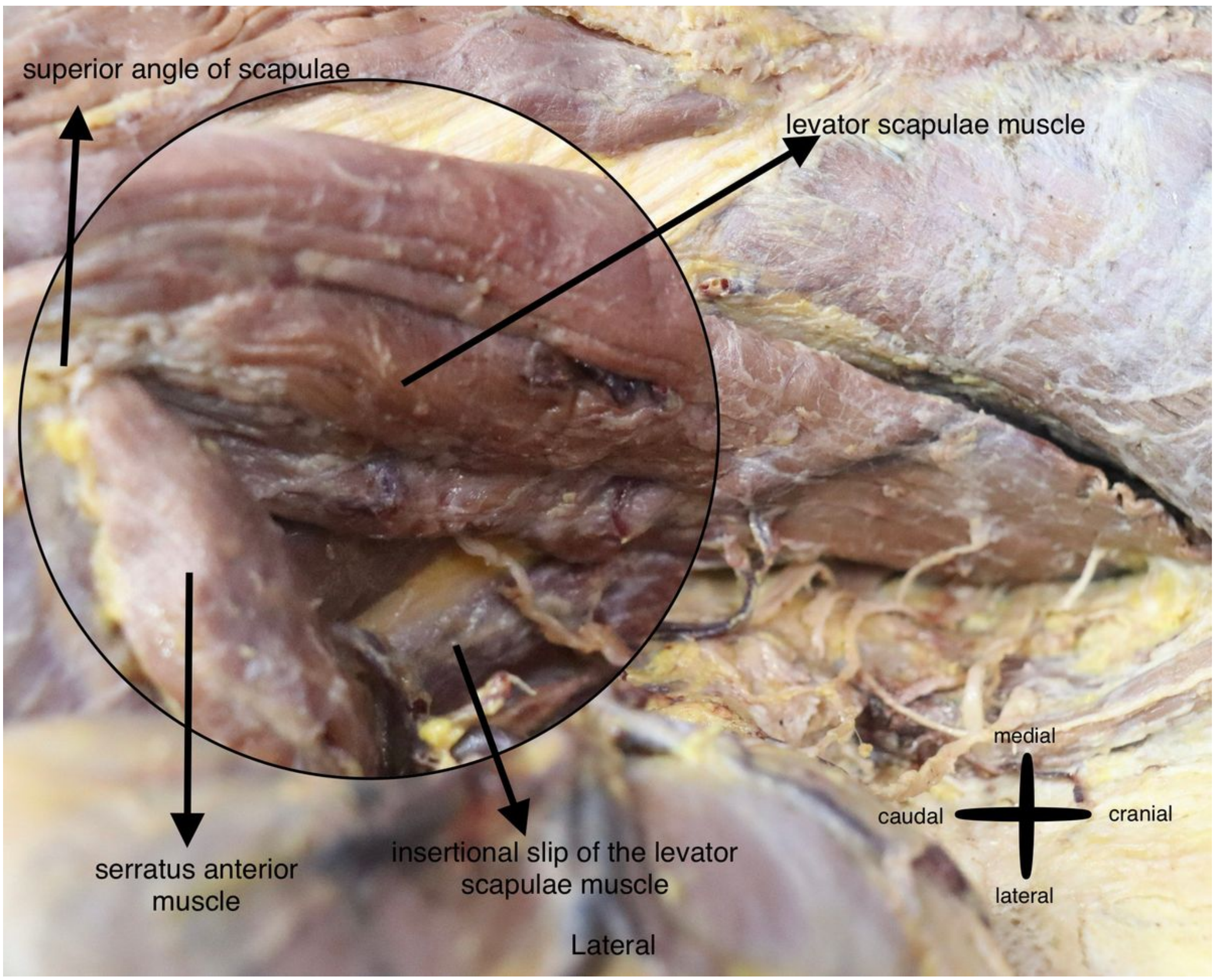

Figure 3

additional insertionel extension of levator scapula and an example of its connection with the serratus anterior and innervation. Yellow stars indicate C3 and C4 spinal nerve roots.

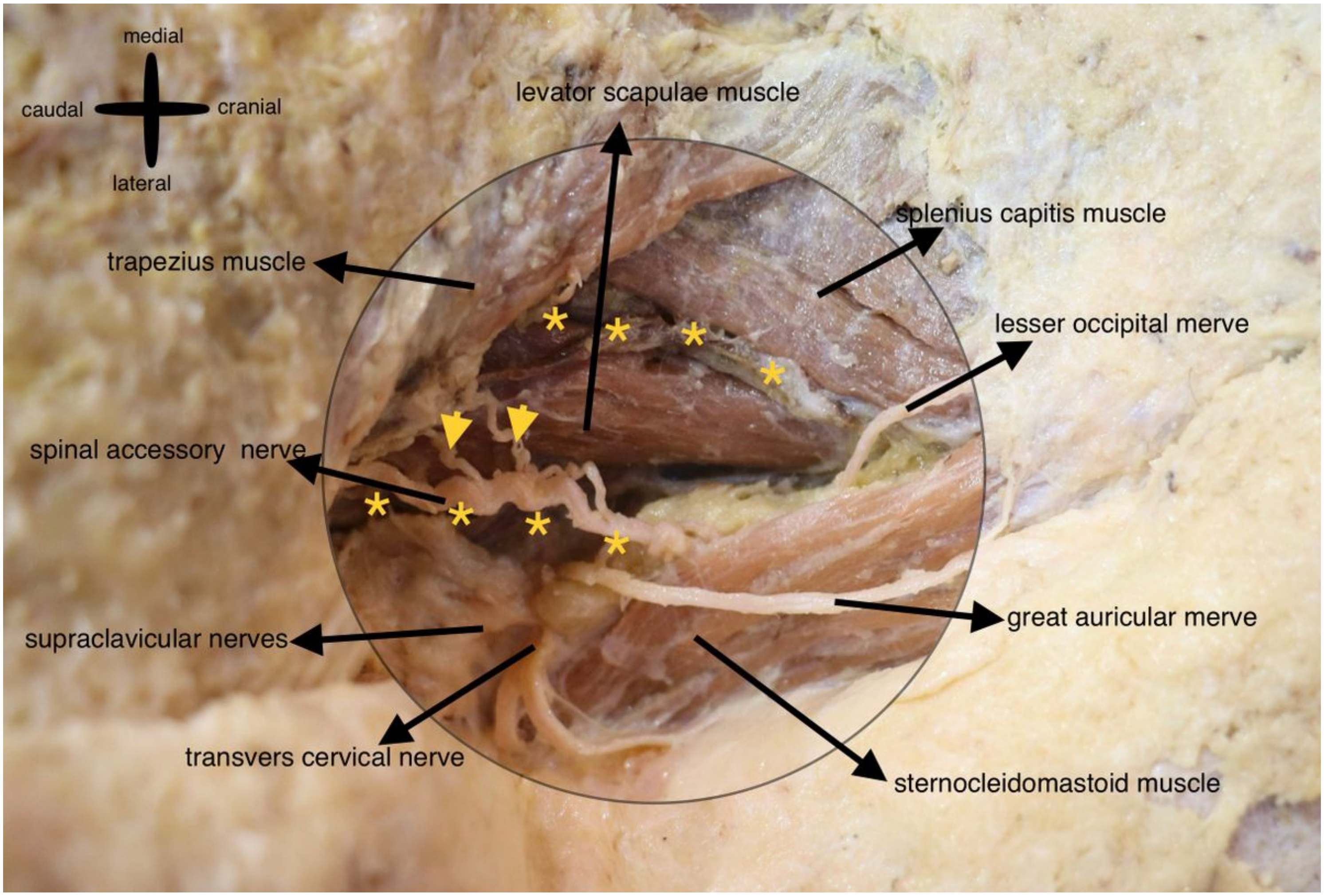

Figure 4

Relationship between the visible edges of the levator scapula muscle and the cutaneous branches of the accessory nerve and cervical plexus in the trigonum cervicale posterius. The yellow stars correspond to the superior and inferior margins of the levator scapula muscle. The yellow small arrows show the branches of the accessory nerve to the trapezius without going under the trapezius muscle.