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An anatomical study on accessory nerve innervation relating to functional neck dissection

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Abstract

Purpose: The present study sought to clarify correlations of this innervation with postoperative dysfunction after functional neck dissection by macroscopic observation of accessory nerve innervation in the neck region and innervation of the sternocleidomastoid and trapezius muscles.

Materials and Methods: The materials used in this study were 35 cadavers provided for anatomical practice to the Department of Anatomy, Tokyo Dental College. The accessory nerve was then identified at the anterior margin of the trapezius muscle, and its innervation in the posterior triangle of the neck was examined in detail.

Results: The superficial cervical vein vascularizes the anterior margin of the trapezius muscle near an area where the main trunk of the accessory nerve innervates the trapezius muscle. The results revealed 3 types of accessory nerve innervation of the sternocleidomastoid muscle: Type A, the not penetrating type; Type B, the partially penetrating type; and Type C, the completely penetrating type. In addition, 5 types of innervation of the trapezius muscle by the main trunk and branches of the accessory nerve were apparent, with the number of branches innervating the muscle ranging from 0 to 4.

Conclusions: Dysfunction following functional neck dissection can thus be avoided by paying attention to not only the main trunk of the accessory nerve, but also the branches. Moreover, when identifying accessory nerve innervation of the trapezius muscle, the superficial cervical vein may offer a useful surgical landmark.

Key words: accessory nerve, sternocleidomastoid muscle, trapezius muscle, functional neck dissection

Introduction

Radical neck dissection as a surgical technique for the treatment of neck lymph node metastasis of head and neck cancer was first reported by Crile[1] in 1906, and began to see wide use after Martin and et al.[2] published their report in 1951. The basic technique for neck dissection involves excision of the neck lymphatic tissue together with the accessory nerve, sternocleidomastoid muscle and internal jugular vein, but this has been pointed out the marked postoperative morphological and functional disorders[3]. In particular, severing the accessory nerve is associated with postoperative shoulder dysfunction[4-10].The accessory nerve, or the eleventh cranial nerve, passes through the jugular foramen and then bifurcates into internal and lateral branches outside the skull base. The lateral branch is a motor nerve that innervates the sternocleidomastoid and trapezius muscles. Severing the accessory nerve thus leads to dysfunction of these muscles. Various techniques for functional (conservative) neck dissection have been introduced to prevent such dysfunction, followed by various modifications of the technique[11-14]. Unlike radical neck dissection, functional neck dissection can prevent postoperative morphological and functional disorders by conserving the accessory nerve, sternocleidomastoid muscle and internal jugular vein[11,15,16]. However, as with radical neck dissection, postoperative dysfunction following functional neck dissection has been reported[17].

While anatomical studies on accessory nerve innervation of the sternocleidomastoid and trapezius muscles have been reported[18-21], none have closely analyzed relationships between neck dissection and postoperative dysfunction. The present study therefore macroscopically examined accessory nerve innervation in the neck region and of the sternocleidomastoid and trapezius muscles, to offer anatomic insight to aid in possibly minimizing postoperative dysfunction after functional neck dissection.

Materials and Methods

The materials used in this study were 35 cadavers (65 sides) provided for anatomical practice to the Department of Anatomy, Tokyo Dental College.

First, the skin and platysma muscle were removed to expose the sternocleidomastoid and trapezius muscles in the neck region. The accessory nerve was then identified at the anterior margin of the trapezius muscle, and its innervation in the posterior triangle of the neck formed by the sternocleidomastoid muscle, trapezius muscle and clavicle was examined in detail (Fig. 1).

1. Positional relationship between accessory nerve and superficial cervical vein in the anterior margin of the trapezius muscle

In neck dissection, the anterior region of the trapezius muscle is the first location at which the accessory nerve is observed. To objectively show the location of the accessory nerve innervating the inner surface of the trapezius muscle, positional relationships between the accessory nerve and superficial cervical vein were examined in 5 cadavers (10 sides). The neck region was fixed so that a perpendicular line could be drawn from the lowest point of the mastoid process to equally divide the line connecting the sternal end and acromial ends of the clavicle. The lower half of the perpendicular line was divided into 5 equal sections, named I-V from the clavicle side. We then determined in which section the accessory nerve and superficial cervical vein innervate and vascularize the trapezius muscle (Fig. 2).

2. Accessory nerve innervation of sternocleidomastoid muscle

The accessory nerve was recognized at the posterior margin of the sternocleidomastoid muscle, and the sternocleidomastoid muscle was resected en bloc from origin to end. On the inner surface of the excised sternocleidomastoid muscle, innervation by the accessory nerve was observed in 35 cadavers (65 sides).

3. Number of accessory nerve braches at the anterior margin of the trapezius muscle, and innervating branches to the trapezius muscle

At the anterior margin of the trapezius muscle, the main trunk of the accessory nerve was observed, and innervation of the trapezius muscle by accessory nerve branches was examined. The accessory nerve and trapezius muscle were then excised en bloc, and accessory nerve innervation on the inner surface of the muscle was analyzed in 26 cadavers (52 sides).

Results

1. Positional relationship between accessory nerve and superficial cervical vein at the anterior margin of the trapezius muscle

Main trunk of the accessory nerve did not innervate the trapezius muscle at Sections I or II, but did innervate the muscle at Sections III (2 sides), IV (5 sides) or V (3 sides).

The superficial cervical vein did not vascularize the trapezius muscle at Sections I or V, but did vascularize the muscle at Sections II (4 sides), III (5 sides) or IV (1 side) (Table 1).

2. Accessory nerve innervation of sternocleidomastoid muscle

Accessory nerve innervation at the inner surface of the sternocleidomastoid muscle was classified into 3 types as follows: Type A, accessory nerve branch innervates the sternocleidomastoid muscle from the cleidomastoid region, while the main trunk of the accessory nerve runs along the inner surface of the muscle without penetrating the sternocleidomastoid muscle before heading toward the trapezius muscle; Type B, the main trunk of the accessory nerve penetrates the sternocleidomastoid muscle from the cleidomastoid region, reappears on the inner surface of the sternocleidomastoid muscle between the cleidomastoid region and the occipital region of the clavicle, then heads toward the trapezius muscle; and Type C, the main trunk of the accessory nerve innervates the sternocleidomastoid muscle from the cleidomastoid region, completely penetrates the lateral surface, then heads toward the trapezius muscle (Figs. 3-5).
The number of the specimens in Types A, B and C were 28 sides (45.9%), 35 sides (50.8%) and 2 sides (3.3%), respectively (Table 2).

3. Number of accessory nerve branches at the anterior margin of the trapezius muscle, and innervating branches to the trapezius muscle

Five types of accessory nerve branching were observed as follows: Type 0, no branches innervate the anterior margin of the trapezius muscle on the inner surface; Type 1, one branch innervates the anterior margin; Type 2, two branches innervate the anterior margin; Type 3, three branches innervate the anterior margin; and Type 4, four branches innervate the anterior margin

(Figs. 8-12). The number of the specimens belonging to Types 0, 1, 2, 3 and 4 were 2 sides (3.8%), 26 sides (50%), 14 sides (30.8%), 6 sides (11.5%) and 4 sides (7.9 %), respectively (Table 3). A greater number of branches tended to be associated with a thinner main branch.

Discussion

As an anatomical landmark for identifying the accessory nerve in the neck region, the great auricular nerve has been used[22]. In the present study, however, the superficial cervical vein, a branch of the external jugular vein, was examined as a more useful anatomical landmark. The findings show that the accessory nerve innervates the anterior margin of the trapezius muscle near the area where the superficial cervical vein vascularizes the anterior margin of the trapezius muscle. When identifying the accessory nerve at the anterior margin of the trapezius muscle during neck dissection, the accessory nerve tends to run slightly superior to the superficial cervical vein. This is an important piece of information when performing of neck dissection.

Regarding accessory nerve innervation of the sternocleidomastoid muscle, past studies have found 2 types. In one type, the accessory nerve partially penetrates the sternocleidomastoid muscle, while in the other, the accessory nerve does not penetrate the sternocleidomastoid muscle[21]. In these reports, frequency of the non-penetrating type was slightly higher than that of the penetrating type. In the present study, the not penetrating type accounted for 28 of 65 cases (43.1%), while the penetrating type accounted for 35 of 65 cases (53.9%). However, another type in which the accessory nerve completely penetrated the sternocleidomastoid muscle was also noted. Unlike the partially penetrated type, innervation of the accessory nerve was different, in that the accessory nerve innervates the muscle from the cleidomastoid region of the sternocleidomastoid muscle, and without reappearing on the inner surface between the cleidomastoid region and the occipital region of the clavicle, penetrates to the lateral surface of the sternocleidomastoid muscle and then heads toward the trapezius muscle. This was seen in two cases (3.1%). When the accessory nerve completely penetrates the sternocleidomastoid muscle, the accessory nerve on the lateral surface of the muscle appears similar to the great auricular nerve and transverse cervical nerve. During neck dissection, the great auricular nerve and transverse cervical nerve that run along the lateral surface of the sternocleidomastoid muscle are severed. The present results thus suggest that an accessory nerve that completely penetrates the sternocleidomastoid muscle may be severed after being mistaken as either the great auricular nerve or transverse cervical nerve.

Previous studies have clarified the distribution of the accessory nerve in the trapezius muscle,

but no studies have investigated branching of the accessory nerve trunk before innervating the trapezius muscle. The present study, therefore, examined branches that bifurcate before innervating the trapezius muscle. In addition, the accessory nerve is a major motor nerve that innervates the trapezius muscle, and the results of this study show that the main trunk of the accessory nerve anastomoses to a branch of the cervical nerve before reaching the trapezius muscle. While this anastomosing branch between the cervical and accessory nerves has been reported in the past[23], whether the anastomosing branch includes centrifugal fibers has not been clarified[23-26]. Previous results have shown that motor nerves are sometimes included[27-32]. While both the cervical and accessory nerves must be analyzed, due to the difficulty in macroscopically observing the cervical nerve, I examined branches that bifurcated from the main trunk of the accessory nerve.

The present study was able to confirm various types of accessory nerve innervation of the trapezius muscle. Tendencies were noted for a greater number of branches to be associated with a thinner main trunk, and for a smaller number of branches to be associated with more medial innervation by the accessory nerve. When identifying the main trunk of the accessory nerve at the anterior margin of the trapezius muscle during neck dissection, the accessory nerve can be better conserved by keeping in mind these tendencies.

We also ascertained the distribution of these branches in the trapezius muscle, and were able to confirm that branches that bifurcated from the main trunk of the accessory nerve before the anterior margin of the trapezius muscle distributed to the upper fibers of the trapezius muscle. In general, the upper fibers of the trapezius muscle together with the levator scapulae muscle are involved in scapular elevation; the middle fibers are involved in scapular adduction; while the bottom fibers are involved in scapular adduction and lowering. When severing the main trunk of the accessory nerve, while scapular elevation is less likely to be affected, adduction will be slightly affected and lowering will be affected [33,34]. Remmler et al.[35] reported that adduction was poor, agreeing with our findings. These data suggest that conserving not only the main trunk of the accessory nerve, but also the branches innervating the upper fibers of the trapezius muscle, is effective in preserving shoulder function, particularly scapular elevation.

Conclusions

The results in this study suggest that when identifying the accessory nerve at the anterior margin of the trapezius muscle, the superficial cervical vein, a branch of the external jugular vein, can be used as a surgical landmark in functional radical neck dissection.

The following 3 types of accessory nerve innervation of the sternocleidomastoid muscle were observed: Type A, accessory nerve does not innervate the sternocleidomastoid muscle; Type B, accessory nerve partially penetrates the sternocleidomastoid muscle; and Type C, accessory nerve completely penetrates the sternocleidomastoid muscle. While Types A and B have been documented, the present study is the first to document Type C.

Regarding accessory nerve innervation of the sternocleidomastoid muscle, we observed that beside the main trunk of the accessory nerve, 1-4 branches of the nerve also innervate the anterior margin of the trapezius muscle, and these branches innervate the upper fibers of the trapezius muscle. When performing neck dissection, the potential individual differences in accessory nerve innervation of the sternocleidomastoid and trapezius muscles must be kept in mind.

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Figure

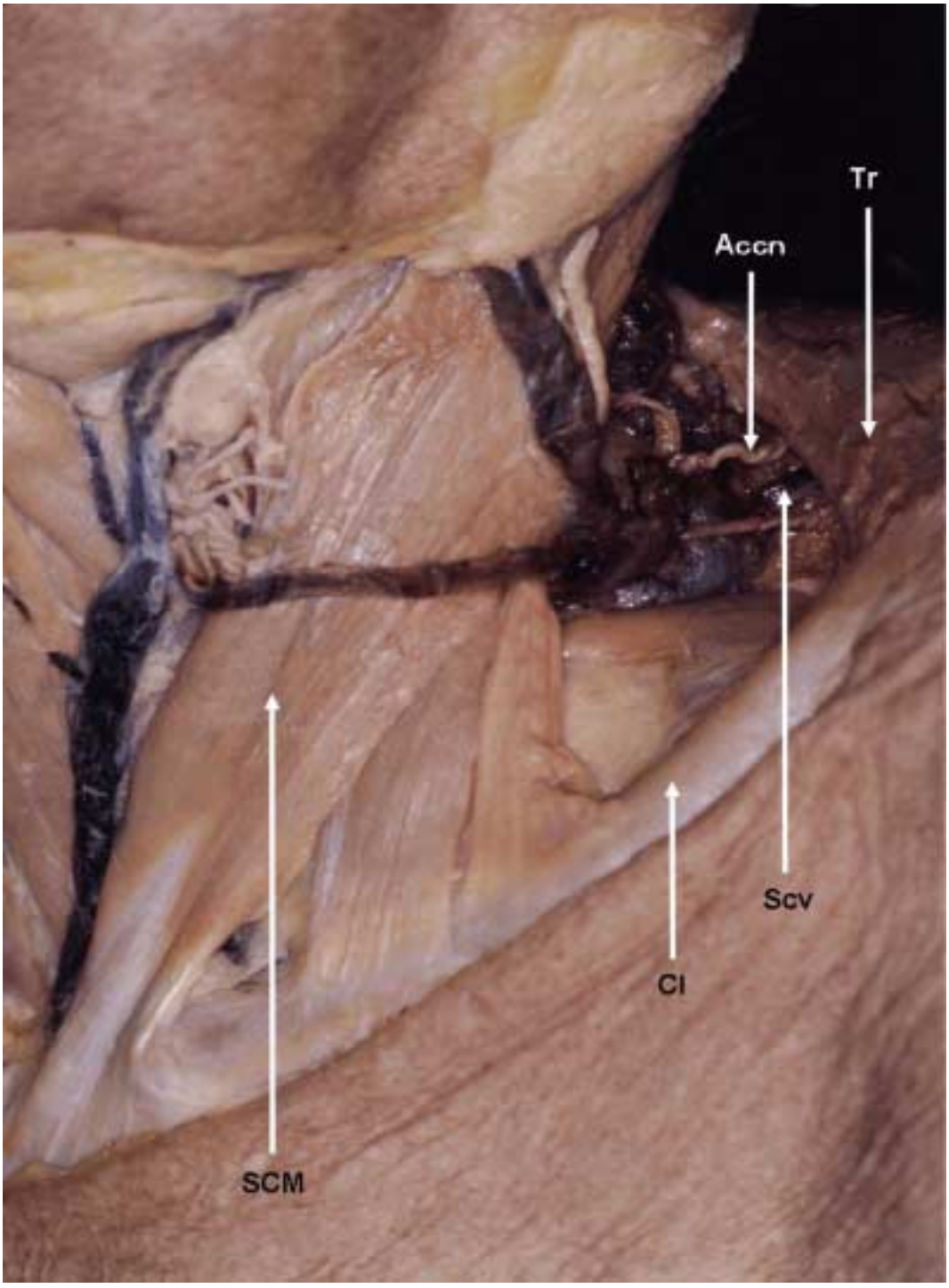
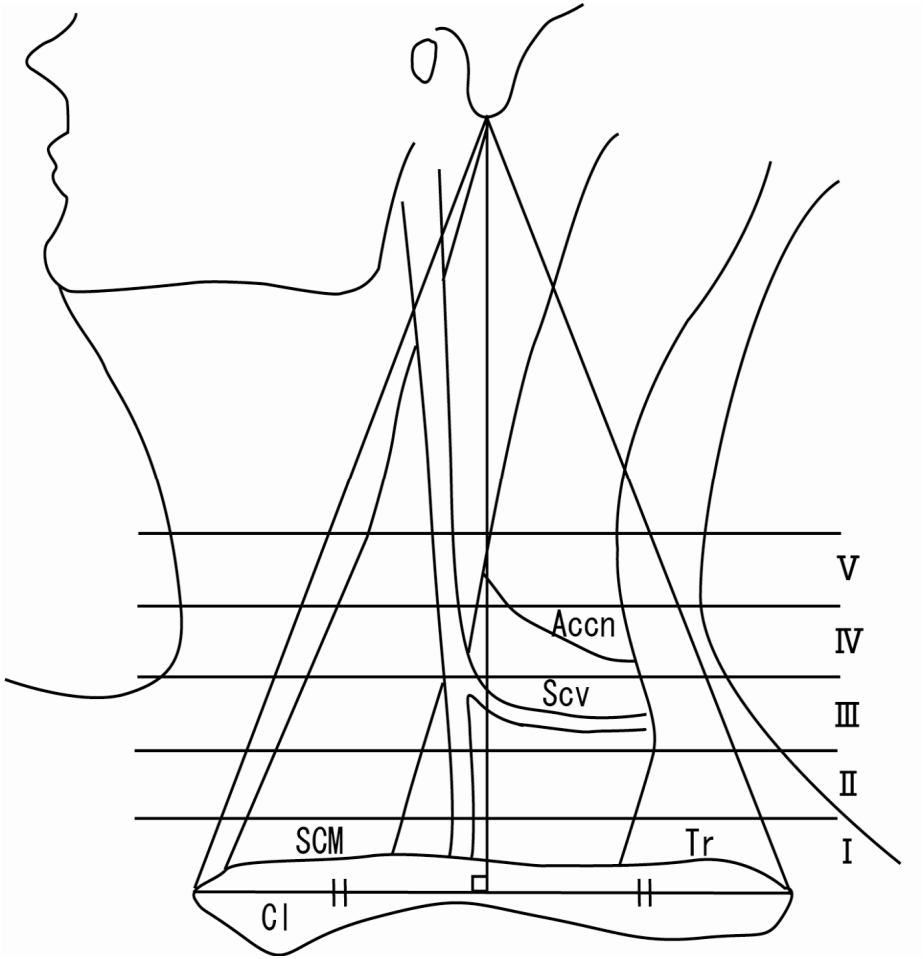


Figure 1. Neck region

SCM: sternocleidomastoid muscle, Tr: trapezius muscle, Accn: accessory nerve, Scv: superficial cervical vein, Cl: clavicle

Figure

Positional relationship between accessory nerve and superficial jugular vein



SCM: sternocleidomastoid muscle;
Tr: trapezius muscle;Accn: accessory nerve;
Scv: superficial cervical vein; Cl: clavicle.

Figure 3. Type A

A branch of the main trunk of the accessory nerve, and not the main trunk itself, penetrates the sternocleidomastoid muscle.(3b: enlarged section of 3a)

Figure 4. Type B

The main trunk of the accessory nerve penetrates the medial surface of the sternocleidomastoid muscle, reappears on the medial surface of the sternocleidomastoid muscle, and then heads toward the trapezius muscle. (4b: enlarged section of 4a)

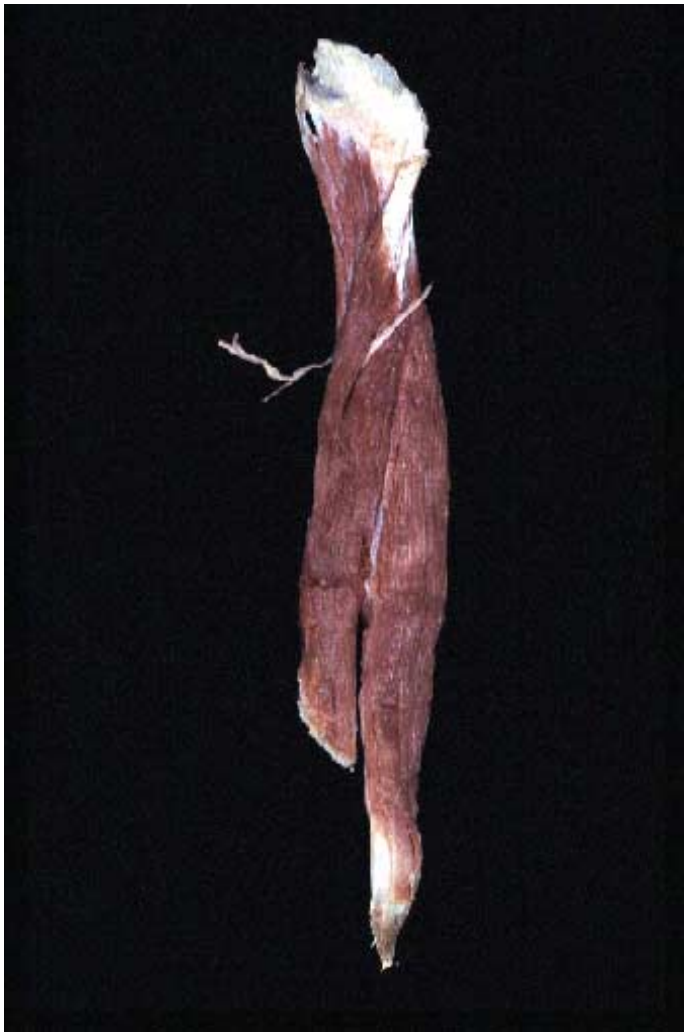


Figure 5. Type C

The main trunk of the accessory nerve penetrates the sternocleidomastoid muscle from the medial surface of the muscle, completely penetrates to the lateral surface, and heads toward the trapezius muscle.
(5b: enlarged section of 5a)

Figure

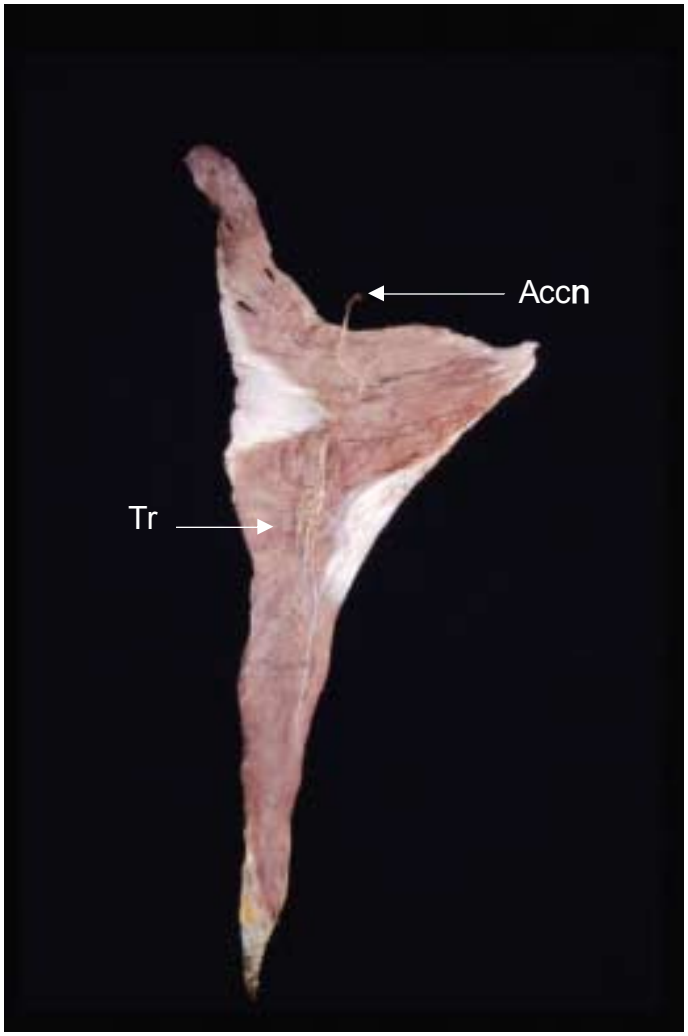


Figure 6. Trapezius muscle (view from inner surface)

Tr: trapezius muscle, Accn: accessory nerve

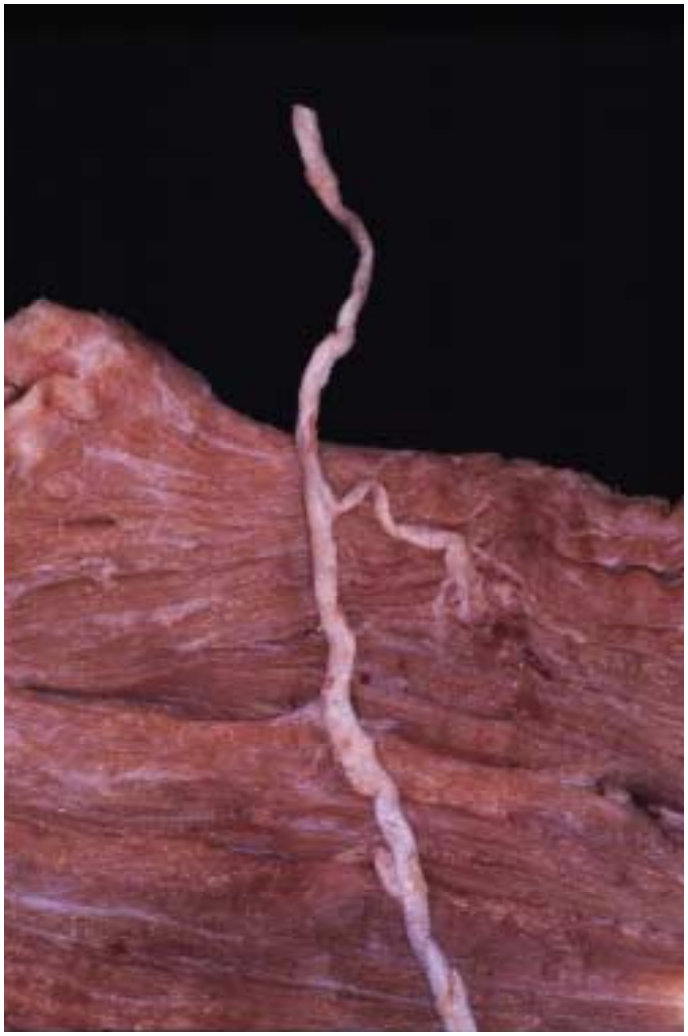


Figure 7. Branching Type 0

In the anterior margin of the trapezius muscle, the main trunk of the accessory nerve has no branch.

Figure 8. Branching Type 1

In the anterior margin of the trapezius muscle, the main trunk of the accessory nerve has one branch.

Figure 9. Branching Type 2

In the anterior margin of the trapezius muscle, the main trunk of the accessory nerve has two branches.

Figure 10. Branching Type 3

In the anterior margin of the trapezius muscle, the main trunk of the accessory nerve has three branches.

Figure 11. Branching Type 4

In the anterior margin of the trapezius muscle, the main trunk of the accessory nerve has four branches.

Table

Table 1: Positional relationship between accessory nerve and superficial jugular vein at the anterior margin of the trapezius muscle

Section of entry	Accessory nerve	Superficial jugular vein
I	0	0
II	0	4
III	2	5
IV	5	1
V	3	0

Table 2: Accessory nerve innervation of the sternocleidomastoid muscle

Branching type	Number of sides
A	28 (45.9%)
B	35 (50.8%)
C	2 (3.3%)

Table 3: Number of accessory nerve branches innervating the trapezius muscle

Branching type	Number of sides
Type 0	2 (3.8%)
Type 1	26 (50%)
Type 2	14 (26.9%)
Type 3	6 (11.5%)
Type 4	4 (7.9%)

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Type 3	6 (11.5%)
Type 4	4 (7.9%)

Table 4: Innervation of trapezius muscle in Type 1

	Number of sides
Medial side, 1 branch	21 (80.8%)
Lateral side, 1 branch	5 (19.2%)

Table 5: Innervation of trapezius muscle in Type 2

	Number of sides
Medial side, 2 branches	5 (31.3%)
Medial side, 1 branch and Lateral side, 1 branch	10 (62.5%)
Lateral side, 2 branches	1 (6.2%)

Table 6: Innervation of trapezius muscle in Type 3

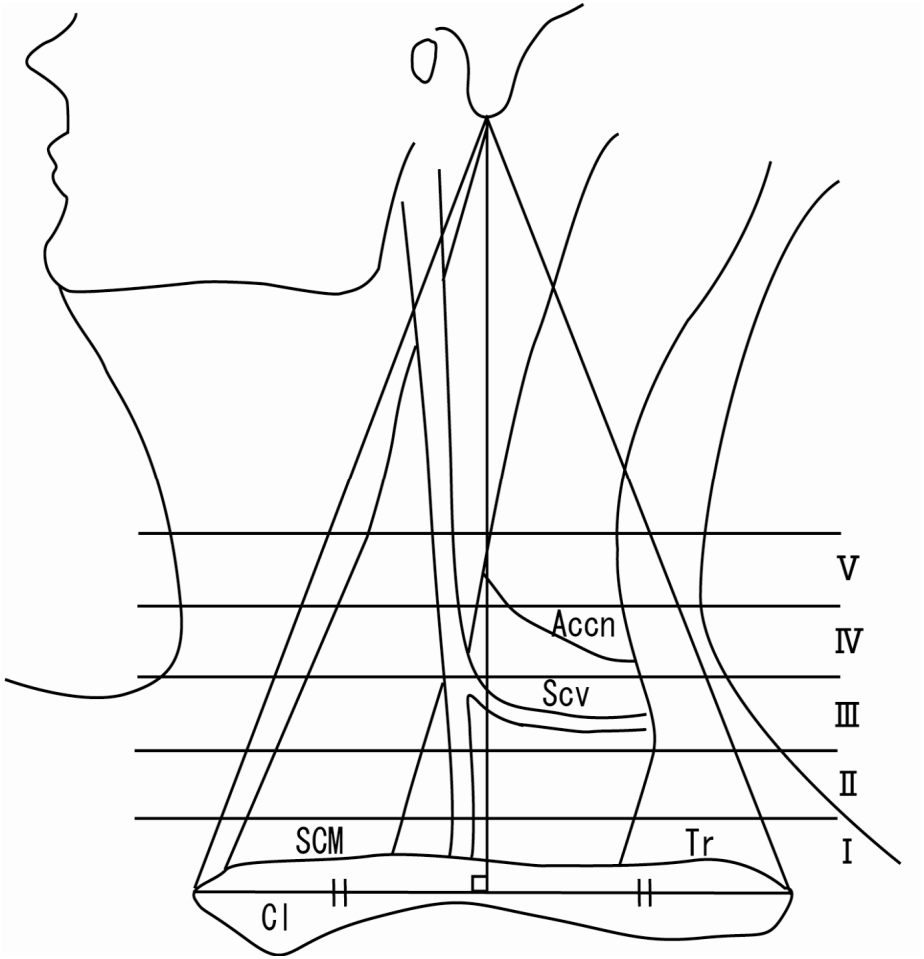
	Side number
Medial side, 3 branches	0
Medial side, 2 branches and Lateral side, 1 branch	3 (50%)
Medial side, 1 branch and Lateral side, 2 branches	3 (50%)
Lateral side, 3 branches	0

Table 7: Innervation of trapezius muscle in Type 4

	Number of sides
Medial side, 4 branches	0
Medial side, 3 branches and Lateral side, 1 branch	1 (25%)
Medial side, 2 branches and Lateral side, 2 branches	3 (75%)
Medial side, 1 branch and Lateral side, 3 branches	0
Lateral side, 4 branches	0

Figure

Positional relationship between accessory nerve and superficial jugular vein



SCM: sternocleidomastoid muscle;
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Figure 3. Type A

A branch of the main trunk of the accessory nerve, and not the main trunk itself, penetrates the sternocleidomastoid muscle.(3b: enlarged section of 3a)

Figure 4. Type B

The main trunk of the accessory nerve penetrates the medial surface of the sternocleidomastoid muscle, reappears on the medial surface of the sternocleidomastoid muscle, and then heads toward the trapezius muscle. (4b: enlarged section of 4a)

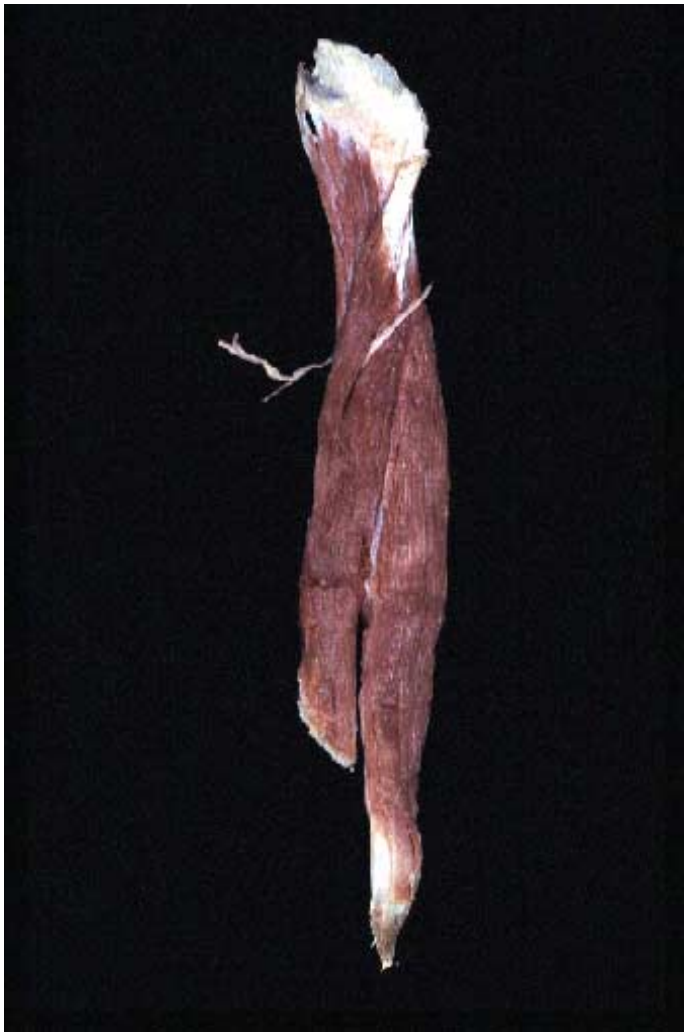

Figure 5. Type C

The main trunk of the accessory nerve penetrates the sternocleidomastoid muscle from the medial surface of the muscle, completely penetrates to the lateral surface, and heads toward the trapezius muscle.
(5b: enlarged section of 5a)