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Original Research Article

THE LEVATOR SCAPULAE MUSCLE – MORPHOLOGICAL VARIATIONS

K. Satheesh Naik [1], Sadhu Lokanadham [2].

*[1] Assistant Professor, Department of Anatomy, Viswabharathi Medical College & General Hospital, Penchikalapadu, Kurnool, Andhrapradesh, India.

[2] Associate Professor, Department of Anatomy, Santhiram Medical College and General Hospital, Nandyal, Andhrapradesh, India.

ABSTRACT

Introduction: Anatomical variations of the levator scapulae are important and therefore clinically relevant. The levator scapulae are now believed to be the leading cause of discomfort in patients with chronic tension-type neck and shoulder pain and a link between anatomical variants of the muscle and increased risk of developing pain has been speculated. The results obtained were compared with previous studies.

Materials and methods: The study was conducted on 32 levator scapulae muscle of 16 cadavers over a period of 3 years. The dissection of head and neck was done carefully to preserve all minute details, observing the morphological variations of the muscle in the department of Anatomy, Viswabharathi Medical College, Penchikalapadu, and Kurnool.

Results: Total 32 levator scapulae muscles were used. All the sample values were measured to 2 decimal places. The average age of the cadavers in the sample was 82.87 years. The oldest cadaver in the sample was 100 years old and the youngest 61 years. Measurements of the proximal and distal attachments and the total length of the muscles were taken. Between 3 and 6 muscle slips were reported at the proximal attachment. Differences were also observed between sides. The first report of a levator scapula muscle with 6 muscle slips at the proximal attachment was described.

Conclusion: In our study we report 3 to 6 muscle slips in our study group. In order to improve the reliability of the results of this study a greater number of specimens should be used, either through further dissection or inclusion of results from imaging techniques. The findings of the study should still be of great interest to clinicians associated with this area of the body. By doing this the speculated link between muscle variation and clinical outcomes such as myofascial pain syndrome could be investigated further. The potential applications and expansions of this study are exciting and may begin to uncover the unexplained mechanisms behind myofascial pain syndrome.

KEY WORDS: Levator scapulae, transverse processes of cervical vertebrae, Origin (proximal attachment), insertion (distal attachment), muscle slips.

Corresponding Author: K. Satheesh Naik, Assistant professor, Department of Anatomy, Viswabharathi Medical College & General Hospital, Penchikalapadu, Kurnool, Andhrapradesh – 518463. Mobile no: 9542093368 **E-Mail:** nsatheesh43@gmail.com.

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INTRODUCTION

The 4 muscle slips of levator scapulae was described by Wood in 1867, at the proximal attachment as the norm. Before his report, 3 muscle slips were always accepted as norm at the origin [1]. During a later study done in Japan in 1964, levator scapulae with 3-5 muscle slips were reported in their investigation [2].

Over time many other accessory attachments of the levator scapula have also been reported. Common variations include; accessory attachment to the occipital bone, mastoid process, ribs one and two, with the trapezius muscle, scalene muscles or even with the serratus muscles. The extent to which the slips separate and reunite also varied greatly [3]. In 2006 an accessory slip of levator scapulae muscle was reported to insert onto the ligamentum nuchae, rhomboid major tendon and also serratus posterior superior muscle [4]. A deviant muscle slip, originating from the upper cervical vertebrae and attaching to the clavicle was also described. This, however, is now considered as a separate muscle and named levator clavicular which is present in 2-3% of the population [5].

The levator scapulae are now believed to be the leading cause of discomfort in patients with chronic tension-type neck and shoulder pain and a link between anatomical variants of the muscle and increased risk of developing pain has been speculated [6]. The position of levator scapula within the floor of the posterior triangle of the neck, make it clinically important for interventional procedures which requires brachial plexus nerve blocks. Consequently, research outlining the anatomical variants of levator scapulae would be of interest to several clinical applications. Limited research and insufficient reports are available on these variations of the levator scapulae. With this study we look at the morphometric differences of the levator scapulae muscles in the cadaver population at the Department of Anatomy, Viswabharathi Medical College,Penchikalapadu, and Kurnool.

MATERIALS AND METHODS

All the specimens used during the research were obtained from the Department of Anatomy Viswabharathi Medical College and Hospital. Each cadaver was embalmed via the right common carotid artery with a mechanical pump infusion over a period of twelve hours. To investigate the levator scapulae muscles, a complicated dissection procedure was developed. The aim was to fully expose the muscle along its entire length. In order to achieve this, the cadaver had to be dissected in the prone- and supine positions to see the origin and the insertion properly. Once this was done, measurements were taken, and descriptions done and documented. For adequate exposure of the levator scapulae, the dissection was done in two stages.

The posterior approach helped to define the insertion of the muscle onto the scapula. The anterolateral approach was to expose the origin of the muscle from the cervical vertebrae. The technique used for dissection was primarily blunt dissection with fingers and forceps. A scalpel was only used for making skin incisions and the scissors for blunt dissection and reflecting of neighbouring muscles. The posterior approach began with the cadaver placed in the prone position. The neck was flexed, and the thorax was lifted by a head support block. Using a disposable surgical scalpel, a midline skin incision was made, starting at the external occipital protuberance, and ending at an imaginary line between the inferior borders of the right and left scapulae. Both these landmarks can easily be palpated beneath the skin. Two other skin incisions were made perpendicular to the midline incision in order to reflect the skin.

The skin and superficial fascia were reflected laterally to expose the back muscles. Trapezius was the first major muscle to be seen. Trapezius was cleared of fascia and fatty tissue, before reflecting the muscle laterally towards its insertion.

The surface of the rhomboids was cleaned to establish the inferior end of the levator scapula insertion. The distal attachment of levator scapula onto the medial border of the scapula and the direction of the muscle towards the cervical vertebrae was now exposed. The levator scapulae are surrounded by large amounts of loose connective tissue and dense irregular connective tissue. These were cleared from the muscle in order to clean the separate muscle slips near its proximal attachment to the transverse processes of the cervical vertebrae. It was not necessary to reflect splenius capitis, but the muscle was cleaned in order to visualize the levator scapula properly. At this point the number of muscular slips could be identified and defined. Once the muscle was cleaned, the relevant measurements were taken (Figure 1). With the aim of completely defining the origins of the levator scapulae muscles and their nerve innervation, the posterior approach was combined with an anterolateral approach. With the cadaver placed in the supine position and a support block used to extend the neck, the anterior triangle of the neck was dissected. A midline skin incision from chin to jugular notch and two transverse incisions; one along the inferior border of the mandible towards the mastoid process and second incision along the clavicle towards the acromion process. Superficial fascia, platysma and veins were removed.

The Sternocleidomastoid muscle was reflected towards its attachment to the mastoid process. The levator scapula was visible within the deep cervical fascia in the floor of the posterior triangle. Once this was done, the delicate process of defining the individual muscle slips and their attachment to the cervical vertebrae was done through blunt dissection. The prevertebral layer of the deep cervical fascia surrounding the muscle was carefully removed. The anterior rami of the cervical spinal nerves C3 and C4 could now be identified. Twig-like branches to the anterior surface of the levator scapula were seen from these nerves. Intermuscular planes were used to define the levator scapula from other muscles in the floor of the posterior triangle. The fibre direction of the muscle and the union of the slips before inserting onto the scapula clearly defined the levator scapulae. Transition from muscle to tendon could be observed clearly, and each tendon could be followed to its attachment onto a vertebra. Measurements related to the origin of the levator scapula could now be made accurately and with ease.

Using a vernier dial caliper (R.S. Baty metric caliper 0-150mm ±0.1mm) the following measurements were made: A: The length of the insertion onto the upper medial border of the scapula. B: Total length of the origin from the cervical vertebrae. C: Length of the muscle from the highest origin to the superior insertion onto the medial border of the scapula. All measurements were repeated three times and the averaged taken for accuracy. Muscle slips at origin were counted and recorded. Photographs for illustration purposes were taken with a Nikon D750 DSLR camera with a 24-120mm lens.

RESULTS

Fig. 1: The posterior view shows the right levator scapula with 5 muscle slips -1. Arrows indicate the 5 slips. The slips were attached to the transverse processes of cervical vertebrae C1- C5.

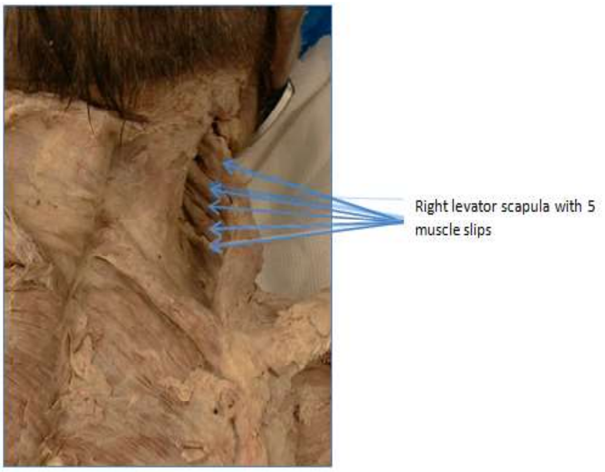

Fig. 2: Anterolateral view of a levator scapula muscle with 6 slips. This was found on the right side of specimen 2016/21. All slips unite near the insertion onto the scapula.

A total of 16 cadavers were used in this study. 14 cadavers during the 2016 to 2019 year batch and 2 specimens were retained from the previous year. In total 32 levator scapulae muscles were used. All the sample values were measured to 2 decimal places. The average age of the cadavers in the sample was 82.87 years. The oldest cadaver in the sample was 100 years old and the youngest 61 years. Of the 16 specimens 12 were male. The leading cause of death in the male population was bronchopneumonia. The study population contained 4 female cadavers. The leading cause of death in the female population was also bronchopneumonia. Respiratory pathologies represented 68.5% of the deaths in the study group. Cardiac pathologies on the other hand only caused 6.7% of the fatalities.

Number and length of Muscle Slips the number of muscle slips at the origin varied greatly. Table 1 summarizes the number of muscle slips of the levator scapulae which were investigated in this study. The average number of muscle slips was 4.11 with a standard deviation of 0.67. Figure 1 illustrates the distribution of the number of slips within the study population.

Three muscle slips were found in 5 of the 32 (15.62%) levator scapulae. At the area of insertion on the medial border of the scapula, the mean length for levator scapulae with three muscle slips was 42.4 mm with a standard deviation of 3.42mm.

The mean distance between superior origin and inferior origin on the transverse process of the cervical vertebrae was 35.6mm ±5.6mm. The mean length of the 3-slip muscle was 112.6mm±16.4mm, measured from superior origin to insertion.

Of the levator scapulae investigated the majority were found to have four muscle slips. 19 of the 32 muscles had four slips, equating to 59.37% of the total. At the area of insertion on the medial border of the scapula the mean length was 48.5 ±5.4mm standard deviation. The mean distance between superior origin and inferior origin on the transverse process of the cervical vertebrae was 47.0 ±6.3 mm. The mean length of the levator scapulae with four slips was 103.3±8.9mm, measured from superior origin to insertion.

The second most common findings were levator scapulae muscles with five slips. In total 7 were identified, corresponding to 21.87% of the total number investigated. The mean length of insertion on the scapula was found to be 47.3 mm with a standard deviation of 5.9mm. The mean distance between superior origin and inferior origin on the transverse process of the cervical vertebrae was 55.9 mm ±6.1 mm. The mean length of the 5 slip muscle was 104.4±11.1mm, measured from superior origin to insertion.

Only one levator scapula muscle was found with six muscle slips; 3.25% of the total. This was found on the right side of cadaver 2016/21. The muscle slips came from the transverse processes of the first 6 cervical vertebrae. The distance between the origin of the most superior and most inferior muscle attachments on the cervical vertebrae was 79.2mm. The area of insertion began at superior angle and continued to the root of the spine of scapula. The length of the insertion was measured at 41.3mm. The overall length of the muscle was measured at 131.4mm.

Table 1: Variation in the number of muscle slips within the total sample; number and percentage.

Number of Muscle Slips	Number of levator scapulae	Percentage of Total (%)
3	5	15.62
4	19	59.37
5	7	21.87
6	1	3.25

Table 2: Statistical calculations used for length of insertion onto the medial border of scapula, comparing the number of muscle slips.

Statistical Calculations	Length of insertion medial border of scapula (mm)		
Number of Muscle Slips	3	4	5
Total Number	5	19	7
Mean (mm)	42.4 ±3.4	48.5 ±5.4	47.3 ± 5.9
Minimum Value (mm)	31.4	33.6	32.3
Maximum Value (mm)	42.8	55.9	51.4

Table 3: Length and number of muscle slips.

Statistical Calculations	Length from superior origin on transverse process of C1 to insertion on medial border of the scapula (mm)		
Number of Muscle Slips	3	4	5
Count	5	19	7
Mean (mm)	112.6±16.4	103.3±8.9	104.4±11.1
Minimum Value (mm)	91.7	93.7	92.5
Maximum Value (mm)	132.9	133.5	128.7

Table 4: Statistical calculations used to compare the length between the superior and inferior origin on the transverse processes of the cervical vertebrae.

Statistical Calculations	Length Between Superior and Inferior origin on the transverse processes of the cervical vertebrae		
Number of Muscle Slips	3	4	5
Count	5	19	7
Mean (mm)	35.6 ±5.6	47.0 ±6.3	55.9 ±6.1
Minimum Value (mm)	30.2	33.7	45.3
Maximum Value (mm)	43	54.8	66.3

Variation within Individual Cadavers: The levator scapulae muscles on the two sides often varied. In 4 out of the 16 cadavers in thestudy, there was a difference in the number of muscle slips between the two sides. The most pronounced difference was in specimen 2017/14 which had 3 muscle slips on the left side and 5 muscle slips on the right side.

DISCUSSION

From our study population of 16 cadavers, the average age at time of death was 82.87 years. The male section of our study group had an average age of 83.87 years. This compares very well with the normal life expectancy of males in South India, which is predicted to be 76.4 years. The average age for females sample was 81 years. This is higher than the expected age for females in South India, which stands at 78.4 years. Another interesting demographic in our study population was the high prevalence of respiratory causes of mortality, and in particular bronchopneumonia. Respiratory pathologies contributed to 78.3% of the total number of deaths in this group. Compare this to the total of mortalities as a consequence of respiratory disease in south India which was reported in 2015 to be 14%. Thought this figure excludes deaths due to lung cancer. Also surprising was the low percentage of deaths caused by cardiovascular diseases which was only 8.7 % of the total in our sample.

The only information available was the cause of death on the death certificate. There are no details regarding the general health of the person before death. As a consequence, it is hard to gauge if the muscle mass and dimensions could have been affected due to co-morbidities, immobility or age. Immobility is a recognized risk factor for bronchopneumonia, which was coincidentally the most common cause of death in our study population. The levator scapulae which were investigated in the study were found to have great variation. The variation in number of slips was much greater than anticipated. Of the 32 investigated levator scapulae just 5 levator scapulae were found to have 3 muscle slips. Each muscle with 3 slips had tendons arising from the transverse processes of cervical vertebrae C1, C2 and the posterior tubercle of the transverse process of C3. They all wrapped around the neck before inserting on the medial border of the scapula.

In total 19 levator scapulae were found with 4 muscle slips. This was the most common finding in our investigation, and this corresponds well with the textbook description in later publications. The muscle slips of the levator scapula originated on the transverse processes of the cervical vertebrae C1-C4. A total of 7 levator scapulae had 5 muscle slips. The slips originated from the first five cervical vertebrae.

In one case the right side the levator scapula had 6 muscle slips. The muscle slips were separated, and each slip originated from a different cervical vertebra. The first two muscle slips were very large and originated from the transverse process of C1 and C2 respectively. The following 4 muscle slips originated from the posterior tubercles of the transverse processes of the cervical vertebrae C3 to C6. After their origin on the cervical vertebrae the slips angled towards the scapula before uniting near the insertion onto the medial border of the scapula. While doing the literature review, no previous reports of a levator scapula with 6 distinct muscular slips of origin, could be found [8].

This investigation not only revealed a great variation of levator scapulae within the sample population, but also variations between levator scapulae within the same cadaver. In 4 cadavers out of the 16 there were different numbers of muscle slips on each side. In another specimen the right side had 5 muscle slips whereas the left had just four. The slips of this muscle had long tendons and thin muscle bellies. In this study, great variation was found within the levator scapulae muscles. The average number of muscle slips found was 4.11 with a standard deviation of 0.67. This compares favourably with other reports in literature. Mardones & Torres found the average number of muscle slips to be 3.95 with a standard deviation of 0.85. Their study contained 11 cadavers and was prompted by the recent applications and surgical techniques involving the levator scapula [8]. Another study also gained similar results, finding the average number of muscle slips originating from the cervical vertebrae to be 4.05 [9]. The standard deviation also indicates that variation in the number of slips was found in other studies.

An anatomical study carried out in Japan observing and documenting the differences in musculature in a population of 50 cadavers, found 66.6% of levator scapulae to have 4 muscle slips. 26.6% had 3 muscle slips and just 3.3% were found to have 5 muscle slips [2]. Interestingly, this contradicts the findings of this study. Although in our study the most common finding was also 4 muscle slips (60.87%), the next most frequent finding was 5 muscle slips (21.74%). 3 slips only accounted for 15.22% of the total levator scapulae investigated. In our study the prevalence of 5 muscle slips are therefore much higher. However, the prevalence of 3 slips is much lower. None of the above-mentioned studies reported a levator scapula with 6 muscle slips.

For the tables comparing the dimensions of levator scapula, I omitted the specimen with 6 slips as this was insufficient for statistical analysis. Instead muscles with 3, 4 and 5 slips were compared. The area of insertion of the levator scapula on the medial border of the scapula was represented by the length between the superior and inferior points of insertion. The standard deviation of the entire population was quite small showing that the length of insertion in the study population was quite similar. The median length of insertion for 3 slips (42.4 mm) was smaller than the insertion of muscles with 4 and 5 slips. The quartile ranges however, showed little difference, especially Q1. Therefore, there was not significant differences in the length of the insertion between 3, 4 and 5 muscle slips.

The length of each muscle was estimated by measuring the distance between the most superior attachments on the transverse process of C1, to the most superior point of insertion on the medial border of scapula. The mean length of the levator scapula was 110.33mm ± 11.61mm. The standard deviation was highest for this measurement, meaning the spread of results was greater. It was found that the length of the muscle increased as the number of muscle slips decreased. The mean length of the muscle was 112.6 mm for muscles with 3 slips, 103.3 mmfor muscles with 4 slips and 104.4 mm for muscles with 5 slips. It must be noted that the standard deviation of the muscles with 4 slips was smallest even though there were 19 levator scapulae with 4 slips recorded, many more than in the other groups. If this study was expanded to include greater numbers and the same conclusions were made, this finding would be very useful in clinical applications.

The mean distance between the superior and inferior origins of the muscle on the transverse processes of the cervical vertebrae was 47.0 ±6.3 mm. The graph shows a gradual increase in the distance between the superior and inferior origin as the number of muscle slips increases. The mean values also demonstrate this progression. It is logical that the distance between the superior and inferior bellies of the muscle increases as the number of slips increases; as the slips tend to rise from the transverse processes of adjacent cervical vertebra. In the cadaver with 6 slips the distance was 79.2mm, which demonstrates this progression the best. The relatively wide dispersion of muscle dimensions and muscle slips obtained from the levator scapulae in this study show that the muscle is far from consistent in nature. This degree of variation should be of interest to clinicians concerned in this area [10].

Following the results obtained from this small study, we believe there is great potential for further research to be carried out on the levator scapula muscle. Firstly, a larger sample would be beneficial in helping to generate more reliable data. This could be achieved by continuing the research and collating the results or indeed combining the results with data from clinical imaging techniques such as MRI, CT or ultrasound. In the introduction, we highlighted the clinical relevance of the levator scapula and its importance with neck and shoulder pain. It has in the past been postulated that anatomical anomalies could play a role in the development of shoulder pain. When considering the delicate balance required, maintaining posture, alignment of the cervical vertebrae, and complex movements of the shoulder, muscular variations could upset this balance and lead to soft tissue pain symptoms. Therefore, it would be of great interest to investigate the levator scapulae in patients who suffer from myofascial shoulder pain with an investigating anatomical / clinical study. Visualisation of the levator scapula has been attempted by using ultrasound in a small sample group. Out of the twenty volunteers recruited, excellent visualisation of the levator scapulae was achieved in 11 out of 20 cases [11]. Although ultrasound is a low cost and simple method of investigation, the reliability and accuracy of the results could not rival that of an MRI scan. Data from MRI scans would be ideal for their accuracy, although they are not done routinely for patients with neck and shoulder pain. This is due to the fact that an MRI scan is unlikely to alter the treatment plan of these patients and is very expensive. An anatomical / clinical study definitely has potential, and calls have been made for such a study [6]. Another possible extension to the project would be to investigate whether there is a higher incidence of complications during a brachial plexus block in patients who have anatomical variations in the posterior triangle, compared to patients without anatomical variations.

Again, this would be difficult as it also relies on accurate visualization of the levator scapulae by using scans. The same principle could be applied to surgical complications, such as radical neck dissection for head and neck cancers and anatomical anomalies. This would have more promise, as most patients with head and neck cancers will have several investigations to visualize the area of concern before surgery.

CONCLUSION

Levator scapulae show variations in the number of muscle slips at the origin from the cervical vertebrae. In recent Anatomy textbooks, 4 muscle slips are described for the levator scapulae. However, in our study we report 3 to 6 muscle slips in our study group. In order to improve the reliability of the results of this study a greater number of specimens should be used, either through further dissection or inclusion of results from imaging techniques. Nonetheless, the findings of the research should still be of great interest to clinicians associated with this area of the body. Future directions could see the study expanded to include patients with neck and shoulder pain. By doing this the speculated link between muscle variation and clinical outcomes such as myofascial pain syndrome could be investigated further. The potential applications and expansions of this study are exciting and may begin to uncover the unexplained mechanisms behind myofascial pain syndrome.

Conflicts of Interests: None

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