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Anatomy Section

# Morphology and Morphometry of the Pectoralis Minor Muscle: A Cadaveric Cross-sectional Study

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## ABSTRACT

**Introduction:** Shoulder pain is a common clinical presentation and can be attributed to an anatomically anomalous insertion of the Pectoralis Minor (PMn) muscle tendon into the glenohumeral joint capsule. Therefore, understanding these anomalous patterns is crucial for clinicians in diagnosing and treating patients to prevent misdiagnosis and iatrogenic injury.

**Aim:** To analyse the morphological patterns in the origin and insertion of the PMn muscle and to assess the morphometric dimensions of the muscle.

**Materials and Methods:** This observational cross-sectional study was conducted on 60 upper limbs from 30 embalmed cadavers of both sexes. The specimens were obtained from the Department of Anatomy, ESIC Medical College and Hospital, Hyderabad, Telangana, India, between November 2018 and January 2023. The PMn muscles were thoroughly examined, and the various patterns in the origin and insertion were recorded. The length of the muscle was measured from the sternocostal junction of the inferior aspect of the fourth rib to the medial border of the coracoid process. The width of the muscle was measured at the midclavicular line and at the insertion. The frequency and percentage of each pattern were recorded and statistically analysed.

**Results:** The present study found that the origin of PMn Type-2 was predominantly observed, with an incidence of 86.6%. Type-1 was observed in 6.7% of the upper limbs, while Type-3 was observed in 6.7% as well. Regarding the insertion of the PMn, Type-1 was predominantly observed, with an incidence of 76.7%. Type-2 was observed in 20% of the upper limbs, and Type-3 in 3.3%. The average length of the muscle was 14.01 cm, while the average width at the midclavicular line and at the insertion were 6.16 cm and 1.69 cm, respectively.

**Conclusion:** A high incidence of Type-2 patterns in the origin, and Type-1 was predominant in the insertion of the pectoralis minor muscle. Knowledge of the morphometric measurements of the PMn muscle would be valuable for surgeons performing surgeries in the shoulder and pectoral region.

**Keywords:** Cadaver, Ligaments, Ribs, Shoulder, Tendons

## INTRODUCTION

Shoulder pathology is a very common clinical presentation and can be due to anatomical anomalous insertion or origin of the PMn muscle [1]. Deviations from the general pattern of PMn origin and insertion are relatively common, with as many as 23% of people demonstrating some abnormal pattern of this muscle [2]. The PMn is a triangular key muscle in the axillary region that arises from the third to fifth ribs near their costal cartilage and from the fascia overlaying the external intercostal muscle. It then runs upwards laterally to form a flat tendon and is inserted into the medial border and upper surface of the coracoid process of the scapula. It has important relations in the axillary region, lying in front of the axillary artery, axillary vein, brachial plexus, and dividing the artery into three parts. The upper border gives attachment to the clavipectoral fascia and is accompanied by the superior thoracic artery, thoracoacromial artery, and cephalic vein, while the lower border gives attachment to the suspensory ligament of the axilla and is accompanied by the lateral thoracic artery [3].

Anomalous origin of the PMn includes an extra slip that extends from the pectoralis minor to the latissimus dorsi, subclavius, coracobrachialis, biceps brachii, and pectoralis major (PMj) [4,5]. Anomalous insertion of the PMn tendon continues over the coracoid process to a distal location in the shoulder. Although the clinical repercussions of these abnormal patterns are typically not significant, there is evidence that the PMn tendon's anomalous insertion into the glenohumeral joint capsule can cause shoulder pain and contribute to subacromial or subcoracoid impingement, stiffness in the shoulders, adhesive capsulitis, or reduced range of motion [6-11]. If it is associated with the absence of the coracohumeral ligament, it can cause a Superior Labrum Anterior to Posterior (SLAP) lesion [1]. A shortened PMn may alter scapular kinematics during arm elevation [12].

Excessive stretching of the shoulder and trauma to the neck can cause tightness in the PMn muscle, leading to symptoms such as pain, weakness, numbness, and tingling in the hand and arm, similar to Thoracic Outlet Syndrome (TOS) [13]. The muscle may be completely absent in cases where the PMj is absent, as seen in Poland's syndrome [14]. Understanding the innervation of the PMn muscle by the medial and lateral pectoral nerves is crucial during breast reconstruction surgery after modified radical mastectomy for breast cancer, axillary dissection, removal of the PMn muscle, and harvesting of the PMj for myocutaneous head and neck island flap surgeries [15].

Various patterns of the PMn muscle are attributed to disturbances in musculature development. The hypaxial part of regional somites develops into the prepectoral muscle mass, which is then divided into superficial and deep entopectoral sheets. The superficial sheet eventually develops into the pectoralis major, while the deep sheet becomes the pectoralis minor and subclavius [1].

The pectoralis minor muscle can become tight or overactive, altering scapular posture and increasing the risk of shoulder impingement, rotator cuff dysfunction, and other shoulder-related disorders. Conversely, PMn weakness or underactivity can lead to scapular instability and poor upper limb function. However, previous studies have not encompassed all the variables of the PMn muscle, with most being case reports focusing solely on insertion patterns [11,12,1]. Therefore, in this study, the authors included all the variables of the PMn muscle and conducted a comprehensive

analysis. The aim of the study was to analyse the morphology of PMn muscle, including patterns in its origin and insertion and also to assess the morphometric dimensions of PMn muscle.

## MATERIALS AND METHODS

The observational cross-sectional study was conducted in the Department of Anatomy at ESIC Medical College and Hospital, Hyderabad, Telangana, India, from November 2018 to January 2023. The cadavers used in the study were obtained through the body donation program, and informed consent was obtained from the donors or their next of kin prior to their death for the purpose of medical education and research.

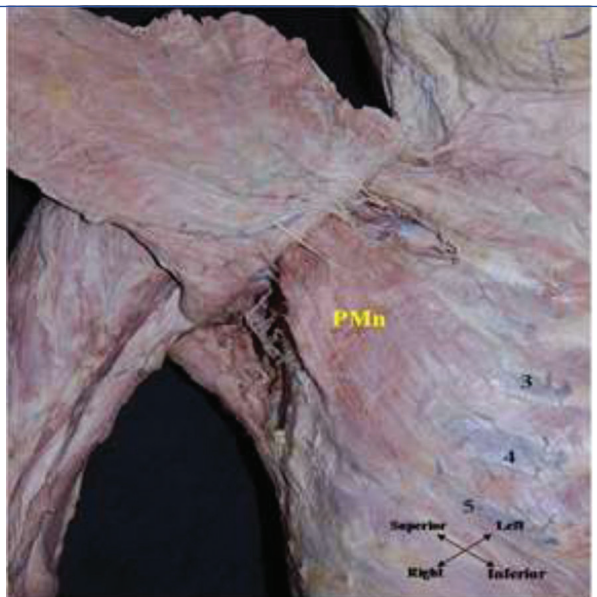
**Inclusion criteria:** A total of 60 upper limbs from 30 embalmed cadavers of both sexes, available in the department of anatomy, were included in the study.

**Exclusion criteria:** Ten specimens with fractured shoulder regions, PMn muscles that had not cleared, deteriorated pectoral regions, and shoulder regions were excluded from the study.

**Data collection:** The morphology and morphometry of the PMn muscle were analysed in a total of 60 upper limbs from 30 embalmed cadavers. Dissection was performed according to the instructions outlined in Cunningham's Manual of Practical Anatomy [16]. The skin and superficial fascia of the pectoral region were reflected, and the PMj muscle was identified. The muscle was cleaned, and the clavicular head of the PMj was dissected and reflected toward its insertion. The branches of the lateral pectoral nerve were identified and their distribution was observed. The clavipectoral fascia was identified, and the medial pectoral nerve was located and its distribution noted. The remaining sternocostal portion of the PMj was dissected and reflected, and the fascia over the PMn was cleaned. The attachments of the PMn were carefully traced.

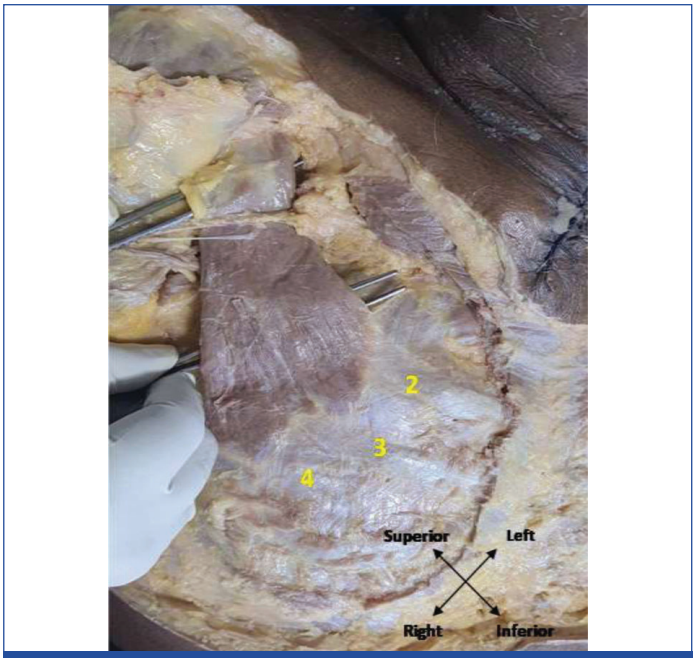
The number of slips from the costochondral junction at the origin and the pattern of insertion at the coracoid process were observed and recorded. As there is no proper classification available for the categorisation of the origin and insertion of PMn muscle [17-19], we categorised the different patterns of insertion and origin of PMn into three types.

The patterns in the origins were classified into three types: Type 1- origin from the 3rd to 5th rib [Table/Fig-1], Type 2 - origin from the 2nd to 4th rib [Table/Fig-2], and Type 3 - origin from the 2nd to 5th rib [Table/Fig-3].

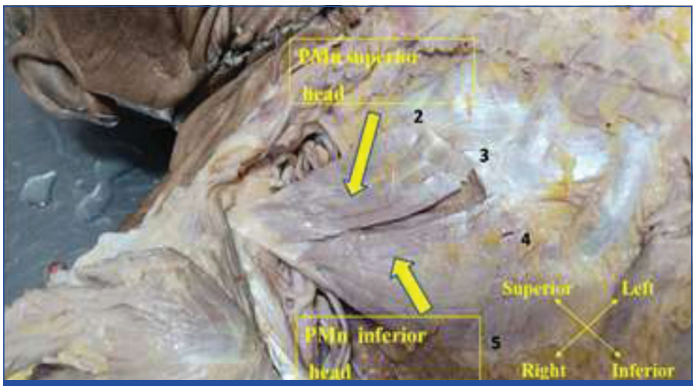



**[Table/Fig-1]:** Showing PMn muscle origin from 3 to 5 ribs.

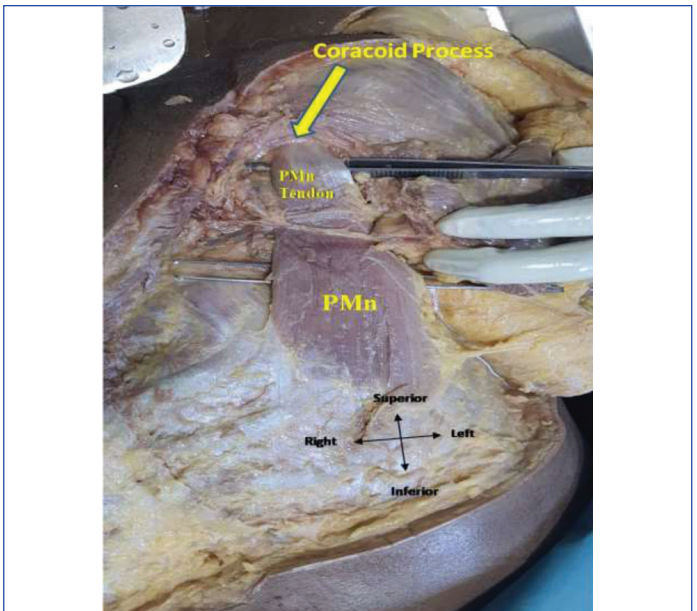
The patterns in the insertion were classified into three types: Type 1- insertion at the Coracoid process [Table/Fig-4], Type 2- fusion with the coracobrachialis [Table/Fig-5], and Type 3- fusion with PMj [Table/Fig-6].




**[Table/Fig-2]:** Showing PMn origin from 2nd to 4th rib.

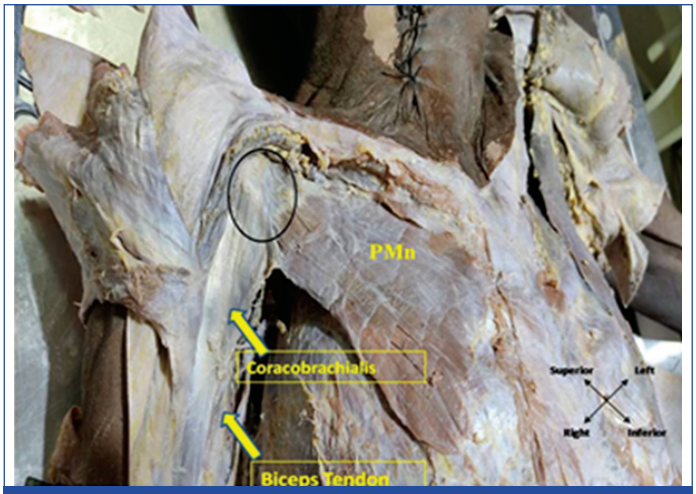



**[Table/Fig-3]:** Showing PMn muscle arised as 2 heads, superior head from 2 and 3 ribs, inferior head from 4 and 5.

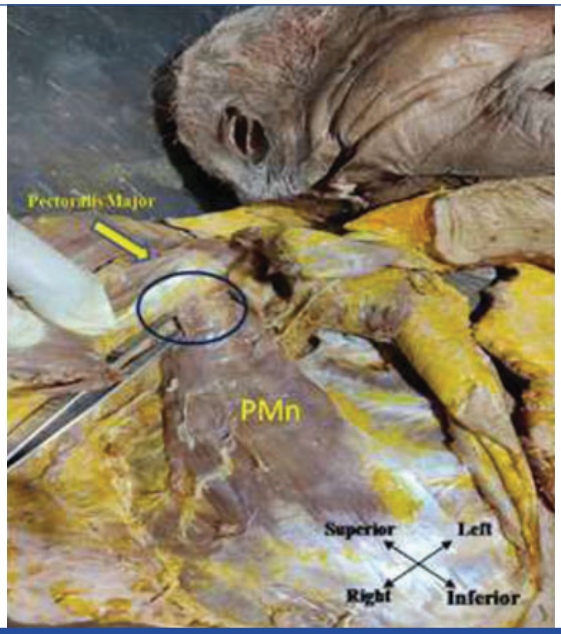



**[Table/Fig-4]:** Showing PMn tendon inserted to the coracoid process.

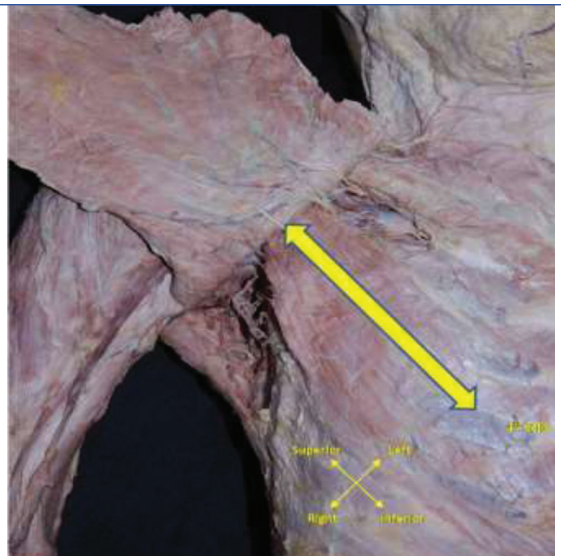
The length of the muscle was measured from the sternocostal junction of the inferior aspect of the fourth rib to the medial border of the coracoid process [Table/Fig-7]. The width of the muscle was measured at the midclavicular line [Table/Fig-8] and also at the insertion [Table/Fig-9]. The length and widths were measured using digital Vernier calipers [20]. The nerve supply was also measured in all the specimens [Table/Fig-10].




**[Table/Fig-5]:** Showing PMn tendon fused with coracobrachialis and biceps tendon.




**[Table/Fig-6]:** PMn muscle tendon fused with pectoralis major.



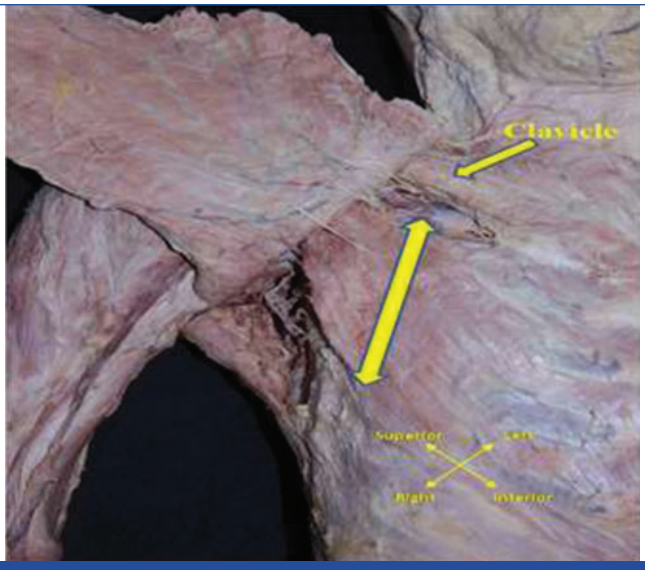
**[Table/Fig-7]:** Showing the measurement of the length of the PMn muscle.

## STATISTICAL ANALYSIS

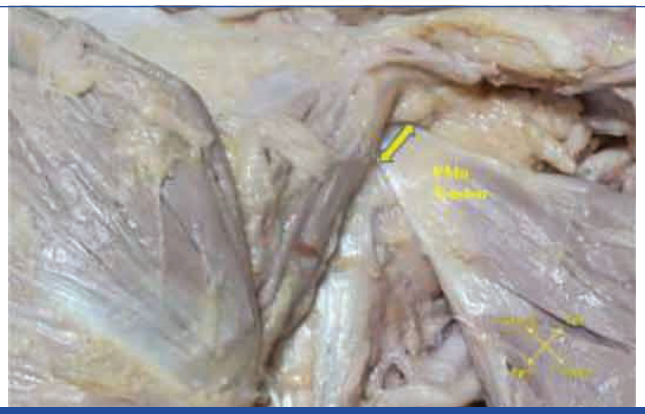
Mean and standard deviations were calculated, and the incidence percentage was determined.

## RESULTS

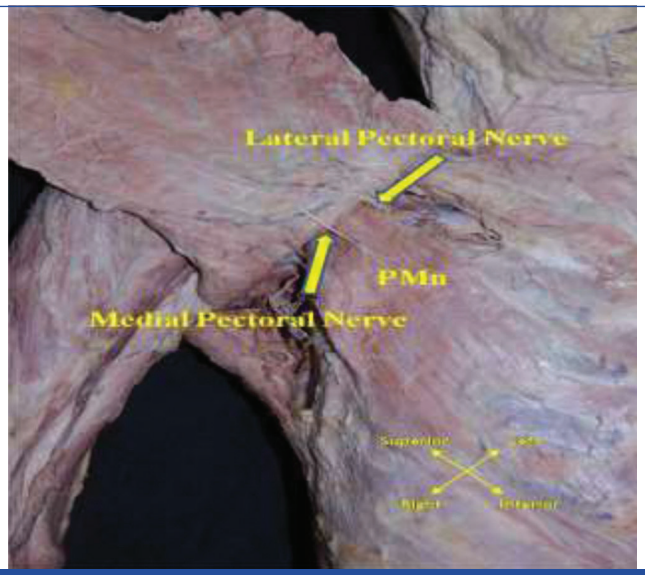
In the present study, out of the 60 limbs examined, 20 were female and 40 were male. The Type-2 pattern (origin from the 2nd to 4th ribs) was predominantly observed, accounting for 86.6% of cases. This differs from what is commonly described in standard anatomy textbooks, where Type-1 (origin from the 3rd to 5th ribs) is considered the most common. In the present study, Type-1 was observed in only 6.7% of specimens, and Type-3 was observed in 6.7% [Table/Fig-11].




**[Table/Fig-8]:** Showing measurement of width of PMn muscle at mid-clavicular line.



**[Table/Fig-9]:** Measurement of PMn muscle tendon width nearer to the insertion.




**[Table/Fig-10]:** PMn muscle innervated by medial and lateral pectoral nerves.

| Type (n=60) | n (%) |
|---|---|
| Type-1 (3rd to 5th rib) | 4 (6.7) |
| Type-2 (2nd to 4th rib) | 52 (86.6) |
| Type-3 (2nd to 5th rib) | 4 (6.7) |

**[Table/Fig-11]:** Showing different patterns in the origin of Pectoralis minor (n=60).

The insertion of the PMn was classified into three types, and their incidences were reported. Type-1, the most common type, was observed in 76.7% of specimens in the present study. Type-2, where the pectoralis minor fused with the coracobrachialis, was observed in 20% of specimens. Type-3, where the pectoralis minor fused with the pectoralis major, was observed in 3.3% [Table/Fig-12].

| Insertion (n=60) | n (%) |
|---|---|
| Type-1-Medial border of coracoid process | 46 (76.7) |
| Type-2-Fused with coracobrachialis and biceps tendon | 12 (20) |
| Type-3-Fused with pectoralis major | 2 (3.3) |

**[Table/Fig-12]:** Showing patterns in the insertion of Pectoralis minor.

The average length of the muscle, measured from the sternocostal junction of the inferior aspect of the fourth rib to the medial border of the coracoid process, average width of the muscle at the mid-clavicular line and mean width of the tendon at the insertion is shown in [Table/Fig-13]. In the present study, normal nerve supply by the lateral and medial pectoral nerves was observed in all specimens.

| Parameters | Range (cm) | Mean±SD (cm) |
|---|---|---|
| Muscle length | 11-18.5 | 14.01±2.08 |
| Muscle width | 3.5-10 | 6.16±1.26 |
| Tendon width | 0.5-4.5 | 1.69±0.87 |

**[Table/Fig-13]:** Showing the mean and standard deviations of the length, width of the pectoralis minor muscle.

## DISCUSSION

The PMn is a small but important muscle located in the anterior chest wall. Despite its small size, PMn plays a crucial role in maintaining posture, shoulder stability, and upper limb function. Although there is some understanding of its anatomy and function, further study is needed to fully comprehend PMn and its implications for human movement and musculoskeletal health. This article emphasises the significance of understanding PMn and highlights its potential benefits for a various professions, including clinical practice, sports medicine, and rehabilitation.

Shoulder pathology is a common clinical presentation and can be attributed to abnormal anatomical patterns. Abnormalities in the morphology and morphometry of PMn can contribute to shoulder pathology. A higher origin of PMn can result in hyperabduction and lateral rotation of the shoulder, which may compress and excessively stretch neurovascular structures, leading to neurological and vascular symptoms in the arm [1]. On the other hand, a lower origin of PMn may act as an accessory muscle of respiration during deep and forced inspiration [21].

In the present study, the origin of PMn was observed in three types. The most predominant type was origin from the 2nd to 4th rib, accounting for 86.6% of cases. Origin from the 3rd to 5th rib was observed in 6.7% of cases, and origin from the 2nd to 5th rib was observed in 6.7%. In a study by Anson BJ et al., they observed 10 types of variations in the origin of PMn, with origin from the 2nd to 5th rib being the most common at 42%. Origin from the 3rd to 5th rib accounted for 28.5% of cases, and origin from the 2nd to 4th rib was observed in 15% of cases. Origins from the 3rd to 4th, 3rd to 6th, and 1st to 5th ribs were observed in 5%, 4%, and 2% of cases, respectively. Origins from the 4th to 5th rib, 1st to 4th rib, and 1st to 6th rib were observed in 1% of specimens each, and 0.5% of specimens showed origin from the 2nd to 6th rib [17].

According to the observations of the present study, the finding that the origin of PMn from the 2nd to 4th ribs was observed in 86.7% of specimens. This percentage was considerably higher than the 15% reported by Anson BJ et al., [17]. The remaining specimens showed origin from the 2nd to 5th ribs in 6.7% of cases and from the 3rd to 5th ribs in 6.6% of cases. In contrast, Anson BJ et al., reported these patterns in 42% and 28.5% of cases, respectively [17]. Therefore, authors propose that the 2nd rib origin pattern should be considered a normal origin of the PMn, and further clinical and anthropological studies are needed to investigate the endemic origin patterns of PMn in the South Indian population [17].

Regarding the insertion of PMn, aberrant insertions into the coracobrachialis, PMj, coracohumeral ligament, and capsule of the shoulder joint can cause shoulder pain, limited range of motion, shoulder stiffness, adhesive capsulitis, or SLAP lesions [22], as well as Thoracic Outlet Syndrome (TOS) [23]. Different authors have described variations in the insertion of PMn [Table/Fig-14] [6,18,19,24,25].

In this study, 76.7% of specimens, PMn was inserted onto the medial border and upper surface of the coracoid process without any fibers crossing over it. However, in 20% of specimens, after insertion onto the coracoid process, most of the fibers blended with the coracobrachialis and biceps tendon, as explained by Soni S et al., [19]. In 3.3% of specimens, most of the fibers blended with PMj muscle, and fewer fibers were inserted onto the coracoid process. This variation has not been reported until now and is not included in the Le Double AFL classification.

When examining the length and width of PMn, which are clinically important as a surgical landmarks due to the structures located below or deep to the muscle and its tendon [21], Borstad JD reported the length of PMn muscles as 15.6 cm. In this study, the mean length of the pectoralis minor was found to be 14.01 cm, measured using a digital vernier caliper scale, which was consistent with the aforementioned study [20]. The mean width of PMn was observed to be 6.16 cm, and the width of the tendon near the insertion was measured for the first time to be 1.69 cm.

In terms of nerve supply, in this study, the lateral and medial pectoral nerves were observed to innervate PMn in all specimens. However, Prakash KG and Saniya K reported variations in the nerve supply

| Author | Sample size | Place and publication year | PMn insertion |
|---|---|---|---|
| Double AFL [18] | 36 Subjects | Paris, France and 1897 | **Type-I:** Deep component of the PMn tendon inserted into the coracoid process, while the superficial part crosses over it to a more proximal structure. |
| | | | **Type-II:** The tendon's majority of fibres adhere to the coracoid process, with only a few passing overit. |
| | | | **Type-III:** Tendon travel over the coracoids process without attaching, and is frequently separated from it by abursa. |
| Soni S et al., [19] | Case Report | New Delhi, India and 2008 | Coracoid process; with few muscle fibres blending with coracobrachialis and biceps brachii. |
| Tubbs RS et al., [24] | Case Report | New York and 2005 | The PMn had no attachment to the corocoid process of the scapula but attached directly to the capsule of the glenohumeral joint. |
| Lee SJ et al., [6] | 335 MR arthrograms | Seongnam-si, Korea and 2010 | Capsule of shoulder joint; mostly associated with absent Coracohumeral Higament (CHL). |
| Musso F et al., [25] | Case Report | Vitoria, Brazil and 2004 | The tendon crossed the superior surface of the corocoid process and fused with the tendon of the supraspinatus muscle prior to insertion on the major tubercle of the humerus head. |
| Present study | 60 sides | Telangana, India and 2024 | Type-1-Coracoid process, Type-2-Tendon fused with coracobrachialis, and biceps tendon Type-3-Tendon fused with pectoralis major. |

**[Table/Fig-14]:** Showing observations of other studies in relation to patterns of PMn muscle insertion [6,18,19,24,25].

of PMn and observed innervation by only the medial pectoral nerve in 88% of specimens, by the lateral pectoral nerve in 6% of specimens, by both the medial and lateral pectoral nerves in 4% of specimens, and directly by a branch from the lateral cord of the brachial plexus in 2% of specimens [15].

### Limitation(s)

Since the above study was conducted on embalmed cadavers, it is important to note that the observed abnormal patterns may not necessarily correlate with functional significance.

## CONCLUSION(S)

The findings of the present study reveal a higher incidence of patterns in the origin and insertion of PMn muscle. These observed patterns, along with the morphometric parameters, can be valuable for surgeons when dealing with pathologies and surgeries in the shoulder and pectoral region. While there is already some understanding of the anatomy and function of PMn, further research is needed to fully grasp its intricacies, clinical implications, and contributions to sports performance. A comprehensive understanding of PMn can lead to advancements in clinical practice, sports medicine, and rehabilitation. Knowledge of the morphological patterns of PMn muscle is crucial for surgeons performing surgeries in the pectoral region, especially around the axillary artery and cords of the brachial plexus, to diagnose and treat patients and prevent misdiagnosis and iatrogenic injury.

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**PLAGIARISM CHECKING METHODS:** [Jain H et al.]

- Plagiarism X-checker: Mar 15, 2023
- Manual Googling: Sep 20, 2023
- iThenticate Software: Nov 15, 2023 (16%)

**ETYMOLOGY:** Author Origin

**EMENDATIONS:** 8

**AUTHOR DECLARATION:**

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- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

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