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## **The pooled prevalence estimation of anomalous insertion of pectoralis minor in cadaveric studies**

**Md. Jawed Akhtar**

Associate Professor, Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

**Nafees Fatima**

Assistant Professor, Department of Anatomy, Patna Medical College and Hospital, Patna, Bihar, India

**Shamir Rahman**

Assistant Professor, Department of Orthopaedics, Patna Medical College and Hospital, Patna, Bihar, India

**Md. Kashif Akhtar**

Junior Resident, Department of Anaesthesia & Critical Care, Nalanda Medical College and Hospital, Patna, Bihar, India  
Corresponding author email: [akhtar0912@gmail.com](mailto:akhtar0912@gmail.com)

**Sanjay Kumar**

Assistant Professor, Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

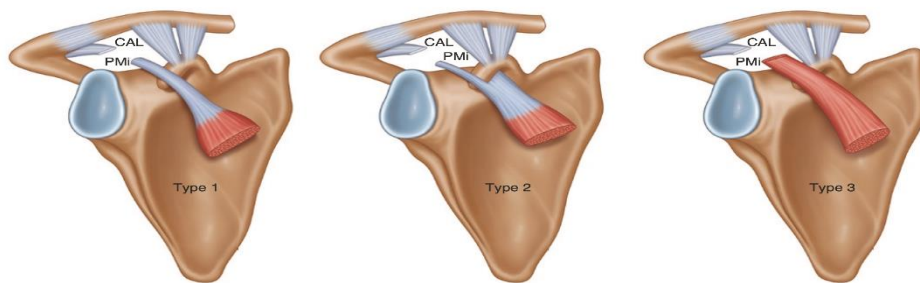
**Abstract**---Introduction: The pectoralis minor muscle originates in the chest wall's third to fifth ribs and inserts on the medial side of the Scapula's coracoid process. It aids in scapulothoracic joint abduction and shoulder downward movement. Since the 19th century, the aberrant insertion of the pectoralis minor beyond the coracoid process has been known. Aim of the study: To measure its pooled prevalence in different populations. Methods: The keywords were generated from MeSH term database. The keywords were combined with the operator to form search strategies. Three significant databases PubMed, Embase, and Google Scholar were used. The data extraction was done from cadaveric studies. Results: The prevalence of anomalous insertion of pectoralis minor was reported to be 1.5-34% (per hundred shoulders in cadaveric dissection in exiting literatures, but its pooled prevalence was 22% (16-31%) (Per hundred shoulders). According to Le Double's classification, there were three sorts of variations of

aberrant tendon insertion. In the literature, the Coracohumeral ligament and the Supraspinatus are two more common locations for the implantation of aberrant tendons. Conclusion: During rotator cuff surgeries, surgeons should be cautious about the pectoralis minor tendon in the rotator interval.

**Keywords**---anomalous, ectopic, pectoralis minor, pooled estimate, prevalence.

## Introduction

The pectoralis minor runs from the rib cage to the coracoid process of scapula in the pectoral region of the thoracic cage, deep to the pectoralis major [1]. It begins as three fleshy slips on the third, fourth, and fifth ribs' exterior surfaces, close to their costochondral joints [2]. On the superomedial border of the coracoid process horizontal portion, the muscle is placed. Various variations in the insertion of the Pectoralis Minor (PMi) tendon from the coracoid process have been reported as attaching the different places by exceeding PMi tendon from the coracoid process. Insertion sites include the coraco-humeral ligament, coracoacromial ligament, glenoid rim, supraspinatus tendon, glenohumeral joint capsule, and infraglenoid humeral tubercles [3]. Le Double noticed inconsistencies in the PMi insertion and divided them into three classes. Type I: The coracoid process is traversed exclusively by the tendon, which then inserts on the previously indicated places. Type II: the tendon and a few muscle fibres cross the coracoid process, inserting on the above-mentioned places. Type III: The entire muscle (not just the tendon) runs over the coracoid process and is placed at several locations, as previously mentioned. (Figure 1) [4]. The pooled estimate of prevalence of ectopic insertion of PMi will be calculated from previous studies.



The three types of variations of the superior attachment of the pectoralis minor muscle as described by Le Double. CAL coracoacromial ligament, PMi pectoralis minor.

Figure 1: Le Double Classification of Anomalous Tendon of Pectoralis Minor.

## Materials and Methods

### Generation of keywords

The keywords were searched from MeSH browser. The keywords were Abnormal, anomalous, ectopic, insertion, attachment, Pectoralis minor, Lesser pectoralis. Three operators were used for Search strategies OR, AND & NOT. The existing

reports were collected from three search engines which are PubMed, Embase, and Google Scholar. The search strategy for PubMed was ((((((Pectoralis minor [Title/Abstract]) AND Ectopic) OR anomalous) OR abnormal) AND insertion) OR attachment) AND (((Rotator cuff tear) OR Shoulder pain) OR impingement syndrome) OR painful arc). Thirty-three studies were collected, and only fifteen literatures dealt with the prevalence of ectopic insertion of PMi. Therefore, fifteen studies were found suitable for data extraction [4-18]. The pooled estimation was done through Prometa 3 software after data extraction. The random effect model was used to estimate the pooled prevalence due to existing racial heterogeneity. The unit of analysis was the ectopic insertion of PMi per hundred shoulders. A total of 2288 shoulders were examined.

## Results

The overall pooled prevalence of ectopic insertion of PMi was 22% (95% CI 16-31%) (per 100 shoulders) (Table-1 Figure 2). The pooled prevalence of ectopic insertion of PMi in American, Chinese, European, Korean, and Japanese are 15%, 10%, 20%, 23%, and 38% (per hundred shoulders), respectively (Figure 3). The prevalence of PMi was increasing with years of publication in regression analysis. The derived regression equation was Pooled prevalence = 0.01\* year of publication -21.16 (P value=0.028 in weighted regression model) (Figure 4).

Table 1. Prevalence of the ectopic tendon of pectoralis minor in different studies and pooled estimation of prevalence

| Studies                         | Population                 | Prevalence (%) | 95% CI (%) |
|---------------------------------|----------------------------|----------------|------------|
| Seib 1938[5]                    | American<br>(White &Black) | 15             | 13         |
| Fang-Dschau 1937[6]             | Chinese                    | 34             | 25         |
| Kolts et al. 2000[8]            | European                   | 79             | 63         |
| Krause 1880[11]                 | European                   | 16             | 10         |
| Le Double 1897[4]               | European                   | 15             | 9          |
| Macalister 1866[17]             | European                   | 15             | 9          |
| Schwarz and Hirtler<br>2019[12] | European                   | 37             | 25         |
| Wagenseil 1964[15]              | European                   | 2              | 0.4        |
| Wood 1866[9]                    | European                   | 15             | 6          |
| Wood 1868[10]                   | European                   | 18             | 13         |
| Hijioka et al. 1977[13]         | Japanese                   | 37             | 28         |
| Tochihara 1933[16]              | Japanese                   | 44             | 33         |
| Yoshimura et al.<br>2007[7]     | Japanese                   | 35             | 25         |
| Lee et al. 2018[14]             | Korean                     | 23             | 15         |
| Gruber 1860[18]                 | Russian                    | 4              | 2          |
| Pooled Estimate                 | Overall                    | 22             | 16         |

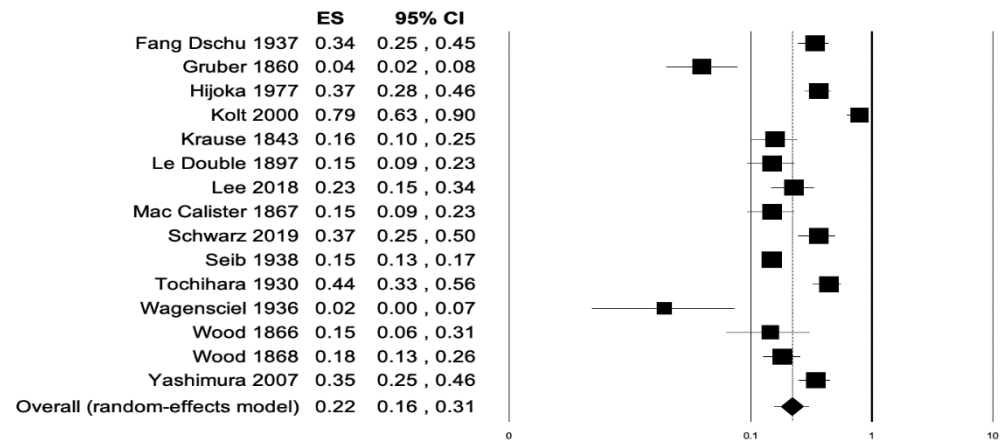


Figure 2: Forest plot of worldwide prevalence (pooled estimate) of PMi based on random effect model. ES; Effect size of prevalence, CI; Confidence interval

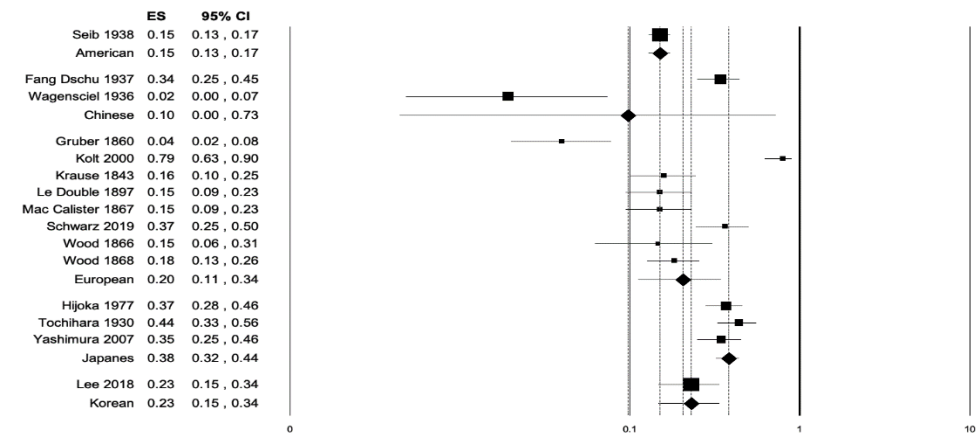


Figure 3. Forest plot of prevalence (pooled estimate) of PMi in different ethnic population based on random effect model. The pooled prevalence of ectopic insertion of PMi in American, Chinese, European, Korean and Japanese are 15%, 10%, 20%, 23%, and 38% (per hundred shoulders).

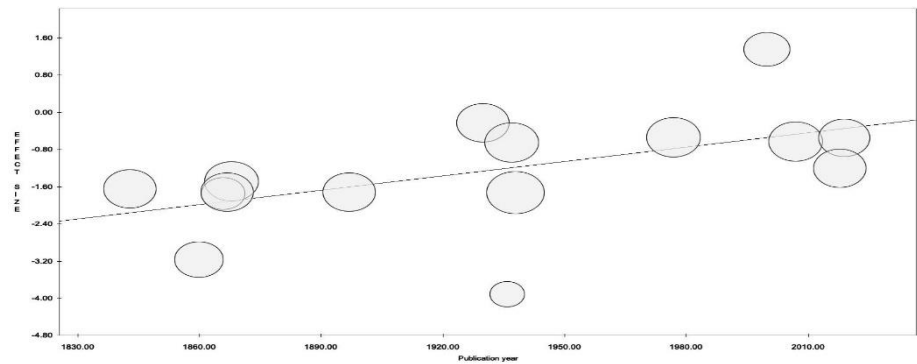


Figure 4. Regression analysis of prevalence of PMi with year of publication

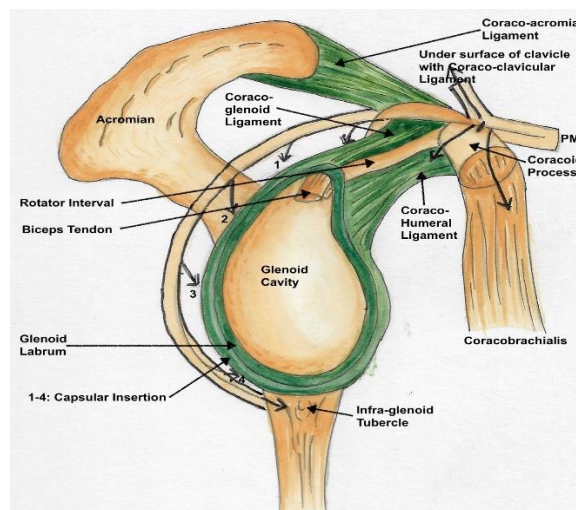


Figure 5. Schematic diagram of possible anomalous insertion of PMi. [1- 4 Capsular insertion of Pectoralis Minor]

## Discussion

The insertion of PMi into the shoulder joint capsule was first reported by Gantzer [19] In 1863, Foltz narrated that the PMi tendon crossed the coracoid process with the aid of a bursa and got inserted deep to Supraspinatus into the fibrous capsule at the greater tubercle [20]. The anomalous tendon of PMi carved a groove on the coracoid process, blending in with Supraspinatus in a fibrous capsule, according to Wood [9]. The PMi tendon crossed the root of the coracoid process and looped downwards and outwards to insert into the shoulder capsule, according to Macalister [17]. The early observations about the insertion of the pectoralis minor were mentioned in Testut's treatises [4,21]. A instance of bilateral capsular insertion of a section of PMi was described by Patten [22]. PMi was inserted into the upper part of the glenoidal lip and the surrounding capsule, according to reports [23].

## Phylogenetic consideration (Figure 5)

The coraco-glenoid ligament was named after Macalister, who was the first to characterize it. He also believes that this ligament is a vestige of the pectoralis minor's more primitive humeral attachment [17]. Brodie suggested that the coracohumeral ligament is PMi tendon that has become detached [24]. PMi became attached to the coracoid process, according to Sicarda. In humans, a superficial portion of the fibres became the coracohumeral and coracoglenoidal ligaments [25]. The coracohumeral ligament, according to Soulier, is a fibrous rudiment of the PMi tendon rather than a separate ligamentous tissue [26]. After a series of dissections in numerous mammals, including lemurs and marmosets, lower monkeys, anthropoid apes, and humans, Huntington determined that PMi insertion eventually shifted cephalad. In man, the primitive humeral insertion of PMi had become capsular, then capsular and coracoidal, and finally totally coracoidal [27]. The gorilla had the most consistent coracoidal insertion (although the humeral insertion has been documented), while the orang and chimpanzee

may have coracoidal, humeral, or both insertions, according to Stewart [28]. Because it was observed in so many very primitive mammals, Lander came to the conclusion that the coracoidal insertion of the pectoralis minor could not constitute a subsequent adaptation. It was transferred to the humerus or another attachment point during the embryological stage [29]. Lander's theory had been refuted by Bland-Sutton, who had adopted the earlier view. Rouviere & Delmas and Tubb et al. bolstered this notion by predicting a negative association between the size of the PMi insertion area and the coraco-pectoral distance [1, 30].

### **Prevalence of ectopic insertion of PMi tendon**

In the Indian population, no extensive investigations have been conducted to determine the frequency of pectoralis minor tendon extension beyond the coracoid process. In previous investigations, the prevalence of PMi anomalous tendons ranged from 1.5 percent to 34 percent. Gruber discovered this variant in eight of 200 shoulders (4.0%), and Macalister identified it in seventeen of 106 shoulders (16 percent) [17,18]. Wood discovered the aberrant tendon in 25 of the 136 shoulders he examined (18.8 percent) [10]. According to Krause, in 16 percent of the cases, the aberrant tendon was linked to the shoulder joint capsule in the coraco-humeral ligament region. In comparison, only 2% of humeral attachments occur to the capsule or larger tubercle [11]. In the dissected specimen, Kolt et al. found a very high prevalence (79 percent) [8]. The authors calculated the prevalence of ectopic PMi in the Japanese population, which was nearly double that of the rest of the world, but did not establish any biomechanical explanations, which could be the subject of future research. Due to the regular reporting of published data, the prevalence of ectopic insertion increased with the publishing of the year. Female and left-sided frequencies were higher than male and right-sided frequencies. Because of failures to identify PMi tendons, the radiological prevalence of ectopic PMi tendon insertion was lower [2,14].

### **Clinical correlation**

Impingement syndrome, thoracic outlet syndrome, rotator cuff injury, and limited external rotation of the shoulder joint have all been linked to anatomical differences in the literature [31, 32]. The pectoralis minor tendon is routinely used to repair the rotator cuff, however its unusual insertion made procedures difficult or hindered glenohumeral joint rotation due to tension [32-34]. Following rotator cuff repair, ectopic tendon attachment may impede fibrotic scar growth in the rotator interval and progress as a superior labrum anterior to posterior lesion (SLAP) [3]. In half a dozen case reports of aberrant insertion of the PMi tendon, shoulder discomfort and dyskinesia were documented. Preoperative imaging such as USG or MRI has lower sensitivity in detecting this pathology, according to a few radiological studies. If linked to the coraco-humeral ligament rather than the coraco-glenoid ligament, this problem may result in a greater loss of range of motion (ROM) [2].

### **Conclusion**

The close relation between the coracohumeral ligament and ectopic insertion of PMi at the rotator interval may be associated with loss of external rotation at the

shoulder joint. This anatomic variation should be suspected if anterior shoulder pain presents or is triggered by forced passive external rotation, even in asymptomatic patients. A prior musculoskeletal USG or MRI assessment should be considered to rule out ectopic insertion PMi in the repair of rotator cuff or tenotomy in impingement syndrome. If this common anomaly is detected, a tenotomy with or without reimplantation of the PMi on the coracoid process should be performed to achieve adequate external rotation. In order to solve the mystery of the high prevalence of ectopic PMI insertion and its impact on rotator cuff biomechanics, phylogenetic and biomechanical investigations could be done in the Japanese population.

Conflict of Interest: Nil

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