

A Retrospective Record-Based Study of Palmaris Longus Muscle Agenesis and Its Anatomical Variations

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Abstract:

Background: The palmaris longus (PL) is a highly variable forearm muscle that may exhibit agenesis and diverse anatomical variations. Although functionally non-essential, its tendon is frequently utilized in reconstructive and tendon-grafting procedures, making knowledge of its anatomical variability clinically relevant.

Aim: To retrospectively assess the occurrence, laterality, sex distribution, and anatomical variations of the PL muscle.

Methodology: A retrospective record-based observational study was conducted in the Department of Anatomy, Darbhanga Medical College, Laheriasarai, Darbhanga, Bihar. Sixty eligible archived cadaveric records were reviewed for PL presence, agenesis, laterality, and documented morphological variations. Data were analyzed using IBM SPSS Statistics version 27.0, with frequencies and percentages used for descriptive analysis.

Results: Bilateral PL presence was documented in 50 records (83.3%), while agenesis occurred in 10 (16.7%). Among agenesis cases, unilateral absence accounted for 70%, comprising right-sided (40%) and left-sided (30%) agenesis, while bilateral agenesis occurred in 30%. Agenesis was observed in 18.4% of males and 13.6% of females. Among records with PL present, normal morphology was observed in 72%, while 28% demonstrated anatomical variations.

Conclusion: The PL showed considerable variability, with notable rates of agenesis and morphological variations, emphasizing the importance of recognizing these patterns during anatomical assessment and reconstructive procedures.

Keywords: Palmaris Longus; Agenesis; Anatomical Variation; Cadaveric Records; Forearm; Retrospective Study.

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Introduction

Palmaris longus (PL) is a fusiform, narrow and slender muscle situated in the anterior compartment of the forearm with a relatively short muscular belly and long distal tendon [1]. The muscle is one of the most variable in the human body, and the presence, morphology, size, origin, insertion and developmental pattern are quite variable [2]. It is highly variable at the anatomical level in some cases associated with the concept of phylogenetic retrogression, and its functional role in the wrist and hand is also thought to be relatively small in comparison to other forearm muscles. Due to these features, the PL has received much anatomical interest related to agenesis and other morphological variability.

The PL is a composite of fibres that include those that arise from the common flexor origin at the medial epicondyle of the humerus and the surrounding deep fascia and intermuscular septa of the anterior compartment of the forearm. Lies between the flexor carpi radialis laterally and the flexor carpi ulnaris medially and deep to it is the flexor digitorum superficialis. The belly of the muscle is short and it merges progressively into a long tendon in the mid-forearm. The tendon continues distally anterior to the flexor retinaculum and broadens before it terminates primarily in the middle part of the palmar aponeurosis [3]. Along its way, the PL tendon partly passes over the median nerve, which is typically located between the PL and flexor carpi radialis as it emerges under the lateral edge of the flexor

digitorum superficialis. These anatomical relationships are significant as any change in the PL can affect its relationship with surrounding neurovascular and muscular structures [4].

The PL is considered a weak flexor of the wrist and is responsible for tightening of the palmar aponeurosis [5]. It also helps to hold and support the skin and fascia in the hand; it may also help to stabilize the superficial palmar structures during grasping tasks. Even with these proposed functions, the muscle is not deemed a necessary muscle for normal hand function. A few studies have shown that the congenital absence of the PL does not significantly affect wrist movement, hand function, or grasp of objects. This functional redundancy can make the absence of the muscle go unnoticed and can only be discovered during physical examination, anatomical dissection, imaging, or during surgery.

One of its most distinctive anatomical variations is agenesis of the PL, which can be either unilateral or bilateral [6]. Along with complete absence, variations include the shape and form of the muscle belly and tendon—and their length, shape, attachment and configuration. This variation is of special anatomical and clinical importance as the PL tendon is often utilized as a donor structure in reconstructive and plastic surgery. It is easily accessible, relatively superficial, and of limited functional value and therefore is a good source of tendon graft. Thus, its location or absence and its recognition of anatomical variations is important for pre-operative evaluation and surgical planning.

PL agenesis and morphological variation can also be helpful in understanding anatomical variation among various populations [8]. Based on the fact that there is also inter-individual variation of the muscle, the anatomical and clinical records of the past can be an efficient approach to the evaluation of its patterns and frequency, in a retrospective manner. Record based studies also can help facilitate comparison of results from various anatomical observations and help document clinically relevant variations that may not otherwise be recorded.

This retrospective study aimed to assess the prevalence of agenesis of the palmaris longus muscle and to record the anatomical variations of this muscle in this context. The study will systematically analyze the archived records to provide knowledge of the anatomical diversity of the PL muscle and its possible role in anatomical education, clinical examination, surgeries, and reconstructive surgeries.”

Methodology

Study Design: The present study was designed as a retrospective record-based observational study to assess the prevalence of palmaris longus (PL) muscle agenesis and to document its anatomical variations. The study was based on previously available

anatomical records obtained during routine undergraduate cadaveric dissections. The records were reviewed systematically to identify the presence or absence of the PL muscle, its laterality, and any documented morphological or anatomical variations. No intervention was performed on the study participants or cadaveric material during the retrospective assessment.

Study Area: The study was conducted in the Department of Anatomy, Darbhanga Medical College, Laheriasarai, Darbhanga, Bihar, India. The department maintained anatomical dissection records generated during routine undergraduate teaching and cadaveric dissection sessions. These archived records served as the primary source of information for the present study.

Study Population: The study population consisted of archived anatomical records of embalmed human cadavers in which examination of the forearm and documentation of the PL muscle had been performed during routine dissection. The records contained information regarding the identification, presence or absence, and anatomical characteristics of the PL muscle in the upper limbs.

Study Duration: The study was conducted over a period of 3 months.

Study Participants

Inclusion Criteria

- Records of human adult cadavers available in the Department of Anatomy.
- Records containing adequate documentation of the PL muscle or flexor compartment of the forearm.
- Records in which both right and left upper limbs had been examined or documented.
- Records in which the presence or absence of the PL muscle could be clearly determined.
- Records containing sufficient anatomical information to identify morphological or structural variations of the PL muscle.
- Records that were complete and suitable for retrospective analysis.

Exclusion Criteria

- Records with incomplete or insufficient information regarding the PL muscle.
- Records in which the forearm or wrist region had been damaged, altered, or inadequately dissected.
- Records with evidence of previous trauma, deformity, or pathological changes affecting the forearm.
- Records in which the PL muscle could not be reliably identified because of poor documentation.

- Duplicate records or repeated observations of the same cadaver.
- Records lacking adequate information for determining the side or anatomical characteristics of the PL muscle.

Sample Size: A total of 60 cadaveric records that fulfilled the predefined inclusion and exclusion criteria were included in the study. The selected records were reviewed for PL muscle agenesis and other documented anatomical variations. Each eligible record was treated as an individual study unit, and the findings were systematically entered into a structured data collection format.

Procedure: The archived anatomical records of 60 eligible cadavers were retrieved from the Department of Anatomy and reviewed retrospectively. The original cadaveric dissections had been performed during routine undergraduate teaching using standard anatomical dissection procedures. During dissection, the flexor compartment of the forearm had been exposed carefully, and the PL muscle had been identified when present. The muscle had been traced from its proximal attachment to its distal tendon, and its morphology, tendon characteristics, and anatomical relationships had been documented. For the retrospective study, the available records were examined to determine the presence or absence of the PL muscle on the right and left sides. Cases in which the muscle was completely absent were classified as PL agenesis. The records were also assessed for unilateral or bilateral agenesis and for documented anatomical variations, including variations in muscle morphology, tendon formation, origin, insertion, or other structural characteristics. Relevant

demographic and anatomical information available in the records was extracted and entered into a standardized data sheet. All extracted information was checked for completeness before statistical analysis.

Statistical Analysis: The collected data were entered, coded, tabulated, and statistically analyzed using IBM SPSS Statistics version 27.0. Descriptive statistics were used to summarize the study findings. Categorical variables, including presence or absence of the PL muscle, laterality of agenesis, sex, and different anatomical variations, were expressed as frequencies and percentages. Where appropriate, associations between categorical variables were assessed using the Chi-square test or Fisher's exact test. The prevalence of PL muscle agenesis was calculated as the proportion of records demonstrating complete absence of the muscle among the total eligible records. A p-value of <0.05 was considered statistically significant.

Result

Table 1 shows the distribution of the 60 study records according to sex. Among the total records, 38 (63.3%) were male, whereas 22 (36.7%) were female. Thus, males constituted the majority of the study records, accounting for nearly two-thirds of the total sample, while females represented slightly more than one-third. The male-to-female distribution was approximately 1.7:1, indicating a higher representation of male records in the study population. Overall, the findings demonstrate a clear male predominance, with males comprising 63.3% compared with 36.7% females among the 60 records included in the analysis.

Table 1: Distribution of Study Records According to Sex		
Sex	Frequency (n)	Percentage (%)
Male	38	63.3
Female	22	36.7
Total	60	100

Table 2 shows the distribution of study records according to the presence or agenesis of the palmaris longus (PL) muscle. Among the 60 records, the PL muscle was present bilaterally in 50 (83.3%) records, indicating that bilateral presence was the predominant finding. In contrast, PL muscle agenesis was observed in 10 (16.7%) records. Thus, the

majority of the study records demonstrated normal bilateral presence of the PL muscle, while approximately one-sixth showed agenesis. Overall, these findings indicate that PL muscle agenesis occurred in a smaller proportion of the study population compared with bilateral presence, with a difference of 66.6 percentage points.

Table 2: Distribution of Palmaris Longus Muscle According to Presence and Agenesis		
Palmaris longus finding	Frequency (n)	Percentage (%)
PL muscle present bilaterally	50	83.3
PL muscle agenesis	10	16.7
Total	60	100

Table 3 shows the distribution of palmaris longus (PL) muscle agenesis according to laterality among the 10 agenesis cases. Unilateral right-sided agenesis was the most common pattern, observed in 4

cases (40%), followed by unilateral left-sided agenesis in 3 cases (30%). Bilateral agenesis was also identified in 3 cases (30%). Thus, unilateral agenesis accounted for 70% of all agenesis cases, whereas

bilateral agenesis represented the remaining 30%. Overall, the findings indicate a slightly greater occurrence of right-sided unilateral agenesis compared

with left-sided and bilateral agenesis, demonstrating variation in the laterality of PL muscle agenesis within the study records.

Table 3: Distribution of Palmaris Longus Agenesis According to Laterality

Pattern of agenesis	Frequency (n)	Percentage (%) among agenesis cases
Unilateral right-sided agenesis	4	40
Unilateral left-sided agenesis	3	30
Bilateral agenesis	3	30
Total	10	100

Table 4 shows the association between sex and palmaris longus (PL) muscle agenesis among the 60 study records. Among males, PL muscle agenesis was observed in 7 (18.4%) records, while the muscle was present in 31 (81.6%) records. Among females, agenesis was identified in 3 (13.6%) records,

whereas PL muscle was present in 19 (86.4%) records. Thus, PL muscle agenesis was proportionally more frequent among males than females, with a difference of 4.8 percentage points. Overall, 10 (16.7%) records demonstrated PL agenesis, while 50 (83.3%) showed the presence of the muscle.

Table 4: Association Between Sex and Palmaris Longus Muscle Agenesis

Sex	PL agenesis present n (%)	PL muscle present n (%)
Male	7 (18.4)	31 (81.6)
Female	3 (13.6)	19 (86.4)
Total	10 (16.7)	50 (83.3)

Table 5 shows the distribution of documented anatomical variations of the palmaris longus (PL) muscle among the 50 records in which the muscle was present. Normal morphology was the most frequently observed finding, accounting for 36 (72%) records. Among the anatomical variations, a reversed muscle-tendon relationship was documented in 4 (8%) records, while accessory or duplicated PL

muscle and variation in tendon formation were each observed in 3 (6%) records. Unusual tendon insertion and abnormal muscle belly morphology were each reported in 2 (4%) records. Thus, normal PL morphology predominated, whereas the documented anatomical variations collectively accounted for 28% of records with PL present.

Table 5: Distribution of Documented Anatomical Variations of the Palmaris Longus Muscle

Anatomical variation	Frequency (n)	Percentage (%) among records with PL present
Normal morphology	36	72
Reversed muscle-tendon relationship	4	8
Accessory/duplicated PL muscle	3	6
Variation in tendon formation	3	6
Unusual tendon insertion	2	4
Abnormal muscle belly morphology	2	4
Total	50	100

Discussion

A total of 60 study records were used, and the study was conducted in a retrospective manner and based on records. A total of 60 study records were used, and the study was done using a record-based retrospective. The bilateral presence was the most common (83.3%), while the presence of PL agenesis was documented in 16.7%. This is a confirmation that PL is a common finding but when it is not present, it does not constitute a pathological condition, but rather is recognised as a normal anatomical variant. The occurrence of PL absence is found to be highly diverse among populations, ethnic groups, study designs, and assessment methods. In a meta-analysis of 68 studies, Pękala et al. (2017) [9] also found

significant differences with respect to PL absence, and between functional and cadaveric studies."

The agenesis of 16.7% in the present study was more than that found in various Indian and Asian studies. In a study of 60 upper limbs of 30 cadavers, Sunitha and Prathap Kumar (2018) [10] found that 5% of the upper limbs lacked a PL, with 3.3% being bilateral and 1.7% unilateral. Lalit et al. (2020) [11], in a North Indian cadaveric study of 62 limbs, reported complete agenesis in 5 limbs (8.06%), while Mathew et al. (2015) [12] observed agenesis in 4 of 48 upper limbs (8.35%). Hence, the current prevalence was almost double that of the findings by Lalit et al. (2020) and Mathew et al. (2015). This difference could be due to the fact that the samples were small, the population was different, or the way

records were documented. Among 385 Indian subjects, Agarwal, 2010 [13] had reported unilateral absence of PL tendon in 16.9% and bilateral in 3.3%, which has varied significantly even within the Indian population.

In the present study, unilateral agenesis was predominant, and bilateral agenesis accounted for 30% of agenesis cases. In 40% of cases of agenesis, there was a unilateral defect on the right side (right-sided unilateral agenesis), while in 30% of cases there was a unilateral defect on the left side (left-sided agenesis). This unilateral absence predominance agreed with Agarwal [10] who reported that 16.9% of the cases had unilateral absence while 3.3% had bilateral absence and Kigera and Mukwaya [14] who reported 3.3% and 1.1% unilateral and bilateral absence, respectively. The present right-sided predominance is, however, different from what has been reported in other studies, which indicate greater lack on the left side. Among 542 subjects, PL absence wasn't found in 5.3% on the right and in 11.1% on the left of right-handed persons, but in 20% on the right and 2.2% on the left of left-handed persons (Erić et al., 2011) [15]. Their results indicated a correlation between absence of one ear and hand dominance. However, since hand dominance was not recorded in the present records, the slightly higher rate of absence on the right side should be taken with a grain of salt.

There was a small sex difference, 18.4% of males versus 13.6% of females with PL agenesis for a difference of 4.8 percentage points. This indicates that there was no significant sex specific pattern of agenesis. Unilateral absence was also reported by Agarwal (2010) with a similar lack of overall association with sex (19.48% males and 14.21% females). Similarly, no significant sex difference ($p=0.605$) was observed (Kigera & Mukwaya, 2011). Thus, the greater percentage that was found in males in this study is not necessarily proof of a sex predisposition.

When morphologic data were available, 72% of the 50 records showed normal morphology and 28% showed some kind of anomaly. Reversed muscle-tendon relationship (8%), accessory or duplicated PL (6%) and variation in the tendon formation (6%) were the most common variations, whereas unusual tendon insertion and abnormal muscle-belly morphology each accounted for 4%. Reversed, duplicated, bifid and hypertrophied PL have been described as recognized anatomical variants [16] (Park, et al., 2010). In their study, Mathew et al. (2015) documented 81.25% normal and 2.08% each for reversed, hybrid, fusiform, fleshy and bifurcated tendons in 48 limbs. Hence, the overall proportion of anatomical variation (28%) was higher than reported by Mathew et al. (2015), who reported about 18.75%.

The results are also similar with Lalit et al. (2020), who found normal morphology in 55 out of 62 limbs (88.70%), complete agenesis in 5 limbs (8.06%), and fleshy fusiform and reversed PL with an accessory muscle in two cases, respectively. Similarly, PL duplication was reported by Sunitha and Prathap Kumar (2018) along with agenesis. These results suggest that the presence or absence of PL should not be the only criterion used for evaluating PL, but also morphology, tendon formation, and insertion.

The significance of these findings is noteworthy since the long and shallow PL tendon is frequently utilized in reconstructive and tendon-grafting procedures. Its absence does not usually produce significant functional disability, however, if it is unusual, such as reversed or hypertrophied, it can help to cause compression symptoms around the wrist. Park et al. (2010) pointed out the clinical importance of the reversed, duplicated, bifid and hypertrophied variants, while Pękala et al. (2017) emphasized the importance of correct diagnosis of the absence of PL before excluding tendon as a source of a graft.

In aggregate, it was determined that 83.3% of the records had bilateral PL, 16.7% showed agenesis, 70% of which were predominantly unilateral PL (PL present on one side and the other side agenesis), and 28% of the records with PL showed anatomical variation. The agenesis rate was higher than that reported in some cadaveric studies but was still within the wide range reported among the populations. Knowledge of both PL agenesis and PL structural variations is important in assessing the anatomy, radiological diagnosis, and considering reconstructive and tendon grafting procedures.

Conclusion

The present retrospective record-based study demonstrated that the palmaris longus muscle was bilaterally present in the majority of the 60 study records (83.3%), while agenesis was observed in 16.7% of records. Unilateral agenesis was more common than bilateral agenesis, with right-sided absence being slightly more frequent than left-sided absence. A modestly higher proportion of agenesis was observed among males than females, although this difference did not indicate a definite sex-related pattern. Among records with PL present, normal morphology predominated (72%), while 28% demonstrated various anatomical variations, including reversed muscle-tendon relationships, accessory or duplicated muscles, tendon formation variations, unusual insertions, and abnormal muscle-belly morphology. Overall, these findings emphasize the considerable anatomical variability of the PL muscle and highlight the importance of recognizing its agenesis and structural variations during anatomical examination and reconstructive or tendon-grafting procedures.

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