

Article

## The Prevalence of Absence of the Palmaris Longus Muscle among Medical Students in Benghazi, Libya

Osama Othman Mohammed Ambarak<sup>1</sup>, Abdullatif H. Annaas<sup>2</sup>, Muna Hassan Elzeadani<sup>3</sup>, Nouralhuda Abdalsalam Abugila<sup>4</sup>, Habeba Salah Zarouk<sup>5</sup>

- 1 Department of Anatomy Faculty of Medicine, University of Benghazi, Benghazi-Libya.
  - 2 Department of Anatomy, Faculty of Medicine, Omar Al-Mukhtar University, Al-Bayda- Libya.
  - 3 Department of Anatomy, Faculty of Medicine, Libyan International Medical University, Benghazi-Libya.
  - 4 Department of Anatomy, Faculty of Medicine, Libyan International Medical University, Benghazi-Libya.
  - 5 Department of Anatomy, Faculty of Medicine, Libyan International Medical University, Benghazi-Libya.
- \* Correspondence: [abdullatif.annaas@omu.edu.ly](mailto:abdullatif.annaas@omu.edu.ly)

**Abstract:** Palmaris longus muscle (PL) is one of the most superficial flexor muscles of the forearm. It is slender and fusiform in shape which lies medial to flexor carpi radialis muscle. It exhibits variability in its prevalence across various ethnicities and geographical areas. Six hundred sixty medical students (275 males, 385 females) aged between 17 to 25 years were included after their consent and examined for the prevalence of absence of the PL muscle tendon. Each student was initially asked to do the Schaeffer's test if not visible then simultaneously followed by Thompson's test and Pushpakumar's "two-finger sign" for the assessment of the PL tendon. 660 medical students in Benghazi-Libya. The overall absence of palmaris longus was seen in 163 students (24.7%) 56 of whom were males (20.4%) and 107 of whom were females (27.8%). Palmaris longus was found absent unilaterally in 14.85% of the students and bilaterally in 9.85% of the students. In comparison to males (20.4%), females had a somewhat higher prevalence of Palmaris longus absent (27.8%). Palmaris longus was absent in 6.52% (43 students) on the right side and in 8.33% (55 students) on the left side. The left-side agenesis was seen in 34 females (8.8%) and 21 males (7.6%). The right-side agenesis was seen in 28 females (7.3%) and 15 males (5.5%). Out of 65 (9.8%) bilateral agenesis, 45 (11.7%) were females and 20 (7.3%) were males. PL muscle is very useful in plastic and orthopedic surgeries. Overall, the palmaris longus was absent in 24.7% of the entire sample. It is possible to carry out more research to determine the relationship between the palmaris longus muscle and several factors including hand dominance, ethnicity, etc.

**Citation:** Ambarak O. O., Annaas A. H., Elzeasni M., H., Abugila N. A., Zarouk H. S. The Prevalence of Absence of the Palmaris Longus Muscle among Medical Students in Benghazi, Libya. *Procedia of Engineering and Medical Sciences* 2024, 9, 10-18.

Received: 7<sup>th</sup> Jan 2024  
Revised: 9<sup>th</sup> Jan 2024  
Accepted: 18<sup>th</sup> Jan 2024  
Published: 20<sup>th</sup> Feb 2024



Copyright: © 2024 by the authors.  
Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license  
(<https://creativecommons.org/licenses/by/4.0/>).

**Keywords:-** Palmaris longus, Thompson's test, and the prevalence of absence.

**Abbreviation:** PL: palmaris longus; LIMU: Libyan International Medical University; SPSS: Statistical Package for Social Sciences.

## 1. Introduction

The Palmaris Longus (PL) muscle is one of the anterior compartment muscles of the forearm. It is spindle in shape with a long tendon. It is defined as one of the most superficial muscles, originating from the medial epicondyle of the humerus. It passes between the flexor carpi ulnaris and flexor carpi radialis muscles, finally, it is ceased in the hand by attaching to the flexor retinaculum, and to a thick deep fascia known as the palmar aponeurosis, which is attached to the skin of the palm and fingers [1, 2]. The main role of this muscle is to assist in the flexion of the wrist by acting as an accessory muscle. Particularly it aids flexor carpi radialis and flexor carpi ulnaris muscles and supports their action in wrist flexion. The muscle is innervated by the median nerve, root values C7 and C8 [1, 3]. The palmaris longus (PL) is one of the most anatomically variable muscles of the body. Its absence, however, is the most prevalent variant, being totally missing in certain situations, either bilaterally or unilaterally, which is more commonly seen on the left side [4]. According to the surgical and anatomical texts, the usual incidence of the PL's absence is 15%, however, this may not apply to all of the world's population [5]. The PL is absent in populations ranging from 0.6% in Korea to 63.9% in Turkey, indicating the wide variation in the muscle's existence across geographic regions [6]. The occurrence of PL agenesis in different ethnic groups indicates relevance in association with the sex and side of the limb; nonetheless, some remain debatable [7]. PL muscle was used clinically by plastic surgeons for grafting in reconstructive and orthopedic procedures due to its position and location [8]. It is important to mention that neither the agenesis nor the presence of the muscle has an effect on the strength or the hand grip [9]. There are other reasons to be interested in the PL muscle besides its potential as a graft. Certain PL muscle abnormalities may contribute to neuropathy (entrapment of the median nerve) or initiate a soft tissue malignancy [10]. A lot of studies have been made regarding the frequency of palmaris longus absence in Korea [11], Iran [12] East Africa [13], and others. Different populations have experienced various rates of PL agenesis. For example, it is 2.9% for Asians, 4.5% for African Americans, and 13.1–14.9% for Caucasians [4]. In a Turkish population, the highest prevalence of PL agenesis ever documented in the literature was 63.91% [14]. This is particularly important considering the lack of comparable data on Arab populations, where there are just a few research on the populations of Egypt [15], Palestine [16], Bahrain [17], and Saudi Arabia [6, 18]. However, the frequency of palmaris longus absence has not been studied yet in Benghazi- Libya. The aim of this study was to determine the prevalence of absence of palmaris longus muscle among medical students in Benghazi, Libya. Also, it will be interesting to compare our results with those of similar research conducted in other Arab populations and other populations worldwide.

## 2. Materials and Methods

### 2.1. Study sample

The subjects for the study consist of 660 undergraduate medical students from Libyan International Medical University, in Benghazi-Libya of which 275 (41.7%) were males and 385 (58.3%) were females. The higher number of female students compared to males resulted from the collection of samples from a student body predominantly composed of women. The age of the students ranges from 17-24 years. The majority of our students were right-handed, 601 (91.1%). Left-handed and ambidextrous participants were 51 (7.7%) and 8 (1.2%), respectively. Inclusion criteria: All medical students from LIMU during the study period. Exclusion criteria: Individuals with myopathic diseases, previous history of trauma to their hands and/or forearms, history of surgical intervention, presence of wrist scars, or abnormality of the upper limb were excluded from the study.

The following information was noted about the students: their gender, age, ethnicity, hand dominance, history of prior surgery or injury, and any evident obesity that would have affected the examination's results.

### 2.2. Study tools

By using several procedures, the volar aspect of the wrist was examined to ascertain whether the PL tendon was present or absent in its typical anatomical location. Initially, the student was requested to do the conventional exam to evaluate the PL tendon. Two more tests were carried out to confirm the absence of the tendon if it could not be seen in the current investigation. The standard test is Schaeffer's test [19], and the other tests are Thompson's test [20], and Pushpakumar's "two-finger sign" test [21]. Schaeffer's Test: the students were instructed to flex their wrists after opposing their thumb to their little finger. If the flexor carpi radialis muscle is present, the tendon can be seen directly medial to it. Other tests were conducted if Schaeffer's test was unable to detect the presence of the PL tendon at the wrist. To do Thompson's Test, make a fist and then bend your wrist against resistance. To accomplish Pushpakumar's Test, fold the first digit over the fourth and fifth digits or make a "peace sign" with your hand. These tests were chosen because they were easy to use and suitable for a wide range of subjects with a significant level of accuracy. The presence or absence of the palmaris longus tendon was recorded for both sides.

### 2.3. Statistical analysis

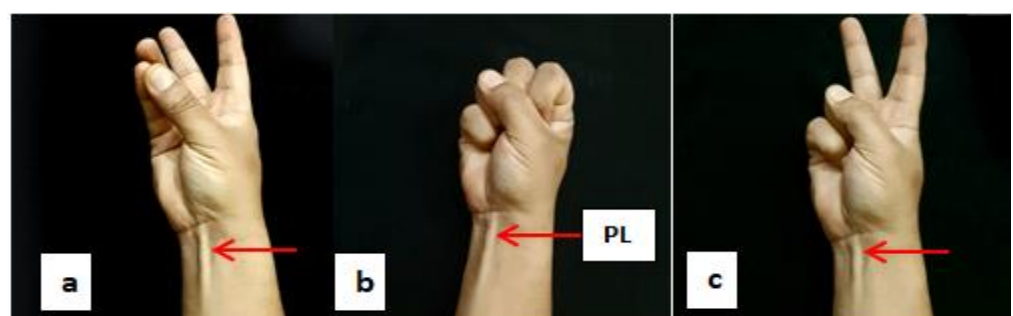
The collected data will be processed, computed, and analyzed using SPSS software version 26. The prevalence of PL muscle agenesis in both males and females will be statistically assessed through an independent sample T-test, with results considered significant when the p-value is less than 0.05.

### 2.4. Ethical considerations

Ethical considerations will be adhered to throughout the study. All students will be provided with information about the research objectives, and verbal consent will be obtained from each of them. Additionally, this research will be approved by the research ethics committee in Benghazi-Libya.

### 2.5. Study period

The study will be conducted in 5 months period, from October 2023 to February 2024.





**Figure 1.** (a) Schaeffer's test, (b) Thompson's test. (c) Pushpakumar's test. Arrow – Palmaris longus tendon. (d & e) PL tendon absent. (LIMU, Benghazi, Libya)

### 3. Result

We examined 660 medical students in LIMU, in Benghazi-Libya. The overall absence of palmaris longus was seen in 163 students (24.7%) 56 of whom were males (20.4%) and 107 of whom were females (27.8%). PL was found absent unilaterally in 98 students (14.85%) and bilaterally in 65 students (9.85%). In comparison to males (20.4%), females had a somewhat higher prevalence of PL absence (27.8%). PL was absent in 6.52% (43 students) on the right side and in 8.33% (55 students) on the left side. The left-side agenesis was seen in 34 females (8.8%) and 21 males (7.6%). The right-side agenesis was seen in 28 females (7.3%) and 15 males (5.5%). Out of 65 (9.8%) bilateral agenesis, 45 (11.7%) were females and 20 (7.3%) were males. Out of 275 males, PL muscle was absent unilaterally in 13.1% (36 students); the distribution on the right was 5.5% (15 students) and on the left side was 7.6% (21 students) whereas bilaterally in 7.3% (20 subjects). The overall prevalence of absence of PL muscle in males was 20.4% (56 students). Out of 385 females, PL muscle was absent unilaterally in 16.1% (62 subjects); the distribution on the right & left was 7.3% (28 students) and 8.8% (34 students) respectively whereas bilaterally in 11.7% (45 students). The overall prevalence of absence in females was 27.8% (107 students). We concluded that the unilateral absence of PL (14.85%) was more frequent than the bilateral absence (9.85%). Unilateral absence was more common in females (16.1%) than males (13.1%). bilateral absence of PL is 11.7% in females but 7.3 % in males.

**Table 1:** The frequency of palmaris longus absence

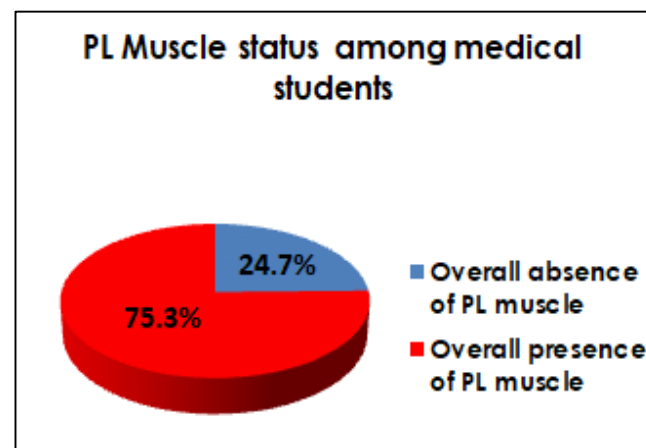
|                    | Number of cases | Percentage (%) |
|--------------------|-----------------|----------------|
| Total              | 660             | 100%           |
| Overall absence    | 163             | 24.7%          |
| Bilateral absence  | 65              | 9.85%          |
| Unilateral absence | 98              | 14.85%         |
| Right side absence | 43              | 6.52%          |
| Left side absence  | 55              | 8.33%          |

**Table 2:** The distribution of absence of Palmaris longus muscle in both sexes.

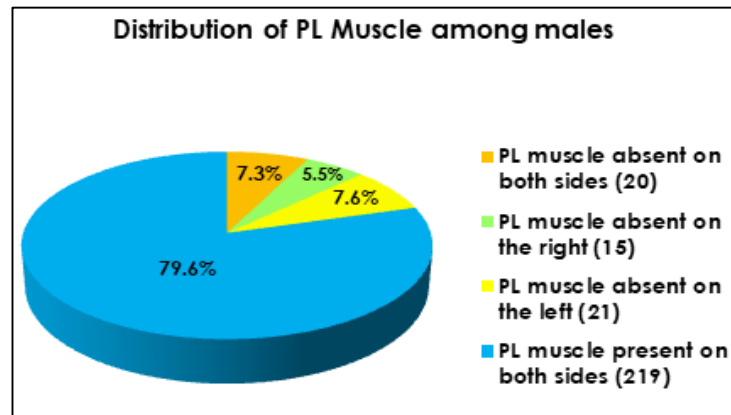
| Number of students | Overall absence of Palmaris longus | Overall presence of Palmaris longus | P-Value      |
|--------------------|------------------------------------|-------------------------------------|--------------|
| Male (275)         | 56 (20.4%)                         | 219 (79.6%)                         | <b>0.029</b> |
| Female (385)       | 107 (27.8%)                        | 278 (72.2%)                         |              |
| Total (660)        | 163 (24.7%)                        | 497 (75.3%)                         |              |

**Table 3:** The distribution of bilateral absence of Palmaris longus muscle in males & females

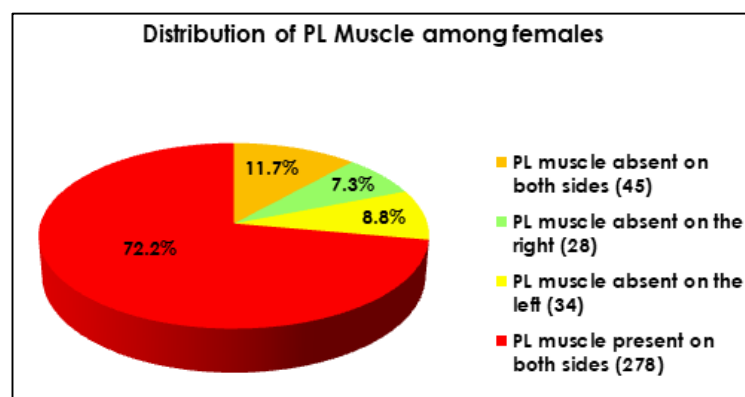
| Absence of PL muscle | Male (%)<br>(275) | Female (%)<br>(385) | Total (%)<br>(660) | P-Value      |
|----------------------|-------------------|---------------------|--------------------|--------------|
| Bilateral absence    | 20 (7.3%)         | 45 (11.7%)          | 65 (9.8%)          | <b>0.061</b> |

**Figure 2:** Pie chart that shows the frequency of presence and absence of Palmaris longus Muscle.**Table 4:** The distribution of unilateral absence of Palmaris longus muscle in males & females.

| Absence of PL muscle | Male (%)<br>(275) | Female (%)<br>(385) | Total (%)<br>(660) | P-Value      |
|----------------------|-------------------|---------------------|--------------------|--------------|
| Unilateral absence   | 36 (13.1%)        | 62 (16.1%)          | 98 (14.8%)         | <b>0.284</b> |
| Left sided absence   | 21 (7.6%)         | 34 (8.8%)           | 55 (8.3%)          | <b>0.585</b> |
| Right sided absence  | 15 (5.5%)         | 28 (7.3%)           | 43 (6.5%)          | <b>0.352</b> |



**Figure 3:** The frequency of presence and absence of Palmaris longus Muscle in males.



**Figure 4:** The frequency of presence and absence of Palmaris longus Muscle in females.

#### 4. Discussion

The human body's most variable muscle in the upper limb is the PL. There are many different kinds of variations, the most prevalent of which is the unilateral or bilateral lack of muscle. An individual's gender and ethnicity are two factors that may affect whether or not they have PL muscle. Due to its extensive use as a donor tendon for transfer or transplant in reconstructive plastic surgery and to administer medication or corticosteroids to treat pain caused by arthritis or carpal tunnel syndrome in the carpal tunnel. Palmaris longus (PL) has been receiving more and more attention. Many authors have written extensive documentation of the PL agenesis's occurrence in various ethnic groups and populations [22]. The prevalence of absence of PL in our sample was found to be 24.7% which is similar to the findings by Hussain et al in Saudi Arabia (24.5%) [18], Ravi et al in Malaysia (23.9%) [23], Venter et al in South Africa (24.4%) [24], Thompson et al in Caucasians (24%) [25], Kose et al in Turkey (26.6%) [26], Morais et al in Brazil (26.5%) [27] And was not much different from that found in some other studies such as Lahiji et al in Iran (22.8%) [12]. The prevalence of absence of PL was close to that of several previous Arab studies, including those involving Saudi Arabia (24.5%) [18], and Palestine (32%) [16], Other studies in Middle Eastern populations found a remarkably higher prevalence of PL absence compared to our results including those in Egypt (50.8%) [15], Saudi Arabia (40.5%) [6], and Bahrain (36.8%) [17]. This value of incidence of absence of PL (24.7%) lies

on the upper limit of the commonly reported range (5 to 25%) in various races [28]. Numerous researches have evaluated the presence of PL muscle in black African populations. According to the findings, the prevalence of its absence varies from 1.5% to 24.4%. Zimbabwe had the lowest absence (1.5%) [29], Ghana (3.8%) [30], East Africa (4.4%) [13], Nigeria (6.7%) [31], Ethiopia (15.3%) [32], and South Africa (24.4%) [24]. The overall prevalence of the absence of the PL tendon in Caucasian populations (European and North American) has been reported between 5.5 and 24% [20, 25]. On the other hand, the overall prevalence of absence of the PL tendon in Asian populations (Chinese, Japanese, Indian, Malaysian) has been reported between 4.6 and 17.2% [7, 33-35]. Cehyan and Mavt [14] reported that 63% of the Gaziantan Turkish population seems to have the highest incidence of PL agenesis but in a recent investigation of the Turkish population the agenesis was found to be only 26% [26]. Our observations of 24.7% absence were considerably higher than values reported in Malaysia (9.3%) [34], Iran 22.8% [12], India 17.2% [33], India 20.2% [36], and Turkey 20% [37]. Other studies showed a lower value such as 4.1% in Korea [11] and 4.6% in China [35]. Compared to research conducted on Asian and other African populations, the prevalence in this study is shown to be higher. This suggests that there is a significant racial variance in muscle agenesis. Numerous studies in the past have indicated that PL absence is more common in women and on the left side which is similar to our study [17, 26, 33, 36]. The present study revealed the prevalence of unilateral absence of PL is higher than that of the bilateral absence accounting for 14.85% and 9.85%, respectively. Unilateral agenesis was more common in these studies [5, 12, 13, 18, 24, 34, 38]. While the bilateral agenesis of the PL muscle was more common in these studies [14, 17, 32]. Some studies have reported significant differences in the frequencies of unilateral (43.2%) and bilateral (20.6%) absence, as seen in the study conducted on the Indian population [36]. Other studies revealed almost equal frequencies of unilateral and bilateral absence of PL [6, 16]. According to our findings, females showed a higher preponderance of unilateral and bilateral absence, which is similar to Sabouba et al [16] and Hussain et al [18].

**Table 5:** Prevalence of absence of Palmaris Longus tendon in various populations

| Population   | Authors                      | Number of participants | Absence of PL (%) |
|--------------|------------------------------|------------------------|-------------------|
| Egypt        | Raouf et al, 2013 [15]       | 386                    | 50.8%             |
| Zimbabwe     | Gangata, 2009 [29]           | 890                    | 1.5%              |
| Nigeria      | Mbaka and Adedayo, 2009 [31] | 600                    | 6.7%              |
| South Africa | Venter et al, 2014 [24]      | 706                    | 24.4              |
| East Africa  | Kigera et al, 2011 [13]      | 800                    | 4.4%              |
| Ethiopian    | Berhe T et al.2014 [32]      | 712                    | 15.3%             |
| Ghana        | Offei et al, 2014 [30]       | 210                    | 3.8%              |
| Saudi Arabia | Hussain et al, 2012 [18]     | 400                    | 24.5%             |
| Saudi Arabia | Alabbad et al, 2018 [6]      | 200                    | 40.5%             |

|               |                                |      |       |
|---------------|--------------------------------|------|-------|
| Palestine     | Malik Sabouba et al, 2022 [16] | 300  | 32%   |
| Bahrain       | Sater et al, 2010 [17]         | 1043 | 36.8% |
| Iran          | Lahiji et al, 2013 [12]        | 1000 | 22.8% |
| India         | Sankar et al, 2011 [39]        | 942  | 28%   |
| India         | Agrawal et al, 2010 [36]       | 385  | 20.2% |
| India         | Kapoor et al, 2008 [33]        | 500  | 17.2% |
| Malaysia      | Roohi et al, 2007 [34]         | 450  | 9.3%  |
| China         | Sebastin et al, 2006 [35]      | 329  | 4.6%  |
| Turkey        | Kose et al, 2009 [26]          | 1350 | 26.6% |
| Turkey        | Alves et al, 2011[37]          | 200  | 20%   |
| Turkey        | Ceyhan O et al. 1997 [14]      | 7000 | 63.9% |
| Caucasians    | Thompson et al, 2001[25]       | 300  | 24%   |
| Serbia        | Eric et al, 2010 [38]          | 800  | 37.5% |
| USA           | Soltani et al, 2012 [4]        | 516  | 14.9% |
| Brazil        | Morais et al, 2012 [27]        | 740  | 26.5% |
| Present study | 2024                           | 660  | 24.7% |

## 5. Conclusion

In the Libyan population, the overall prevalence of unilateral and bilateral PL tendon absence was 24.7%. It is higher compared to what is quoted in standard textbooks (15%). The absence of the PL tendon in females was statistically more common than in males. Unilateral absence of PL was more frequent than bilateral absence. Further studies can be conducted to establish a relationship between the presence of the PL muscle and different determinants such as ethnicity and hand dominance etc. It is very useful and important for the surgeon, plastic surgeon, as well as the ophthalmologist.

**Limitations:** Our study has certain limitations. Potential bias may arise from the higher proportion of female participants in comparison to male participants, particularly if our results are generalized to the total Libyan population.

**Acknowledgments** The authors of this work wish to thank the students in the Faculty of Medicine, at Libyan International Medical University for their help in collecting the sample and doing the research.

## References

1. Drake, R., A.W. Vogl, and A.W. Mitchell, *Gray's anatomy for students E-book*. 2009: Elsevier Health Sciences.
2. Kassim, N.M., et al., *The Incidence of Agenesis of Palmaris Longus Muscle Among Multiracial Medical Students of University Malaya, Malaysia*. Indian Journal of Surgery, 2020. **82**: p. 486-491.
3. Snell, R.S., *Clinical anatomy by regions*. 2011: Lippincott Williams & Wilkins.
4. Soltani, A.M., et al., *The variation in the absence of the palmaris longus in a multiethnic population of the United States: an epidemiological study*. Plastic Surgery International, 2012. **2012**.
5. Nasiri, E., M. Pourghasem, and H. Moladoust, *The prevalence of absence of the palmaris longus muscle tendon in the north of Iran: a comparative study*. Iranian Red Crescent Medical Journal, 2016. **18**(3).



6. Alabbad, A., et al., *The Frequency of Palmaris Longus Absence among Female Students in King Faisal University in Al-Ahsa, Saudi Arabia*. The Egyptian Journal of Hospital Medicine, 2018. **70**(11): p. 1959-1962.
7. Sebastin, S., et al., *The prevalence of absence of the palmaris longus—a study in a Chinese population and a review of the literature*. Journal of Hand Surgery, 2005. **30**(5): p. 525-527.
8. Javaid, Q., A. Usmani, and A. Surti, *Clinical assessment of absence of palmaris longus muscle and its association with ethnicity*. JPMA, 2023. **73**(1029): p. 1.
9. Javaid, Q., *Prevalence of agenesis of palmaris longus in male and female genders on clinical examination-a review*. JPMA. The Journal of the Pakistan Medical Association, 2022. **72**(4): p. 733-737.
10. Georgiev, G.P., *Palmaris longus muscle variants: well known, but what's new*. Int J Anat Var, 2019. **12**(001).
11. Kyung, D.-S., et al., *Different frequency of the absence of the palmaris longus according to assessment methods in a Korean population*. Anatomy & Cell Biology, 2012. **45**(1): p. 53-56.
12. Lahiji, F.A., K. Ashoori, and M. Dahmardehei, *Prevalence of palmaris longus agenesis in a hospital in Iran*. Archives of Iranian medicine, 2013. **16**(3): p. 0-0.
13. Kigera, J.W. and S. Mukwaya, *Frequency of agenesis palmaris longus through clinical examination-an East African study*. PloS one, 2011. **6**(12): p. e28997.
14. Ceyhan, O. and A. Mavt, *Distribution of agenesis of palmaris longus muscle in 12 to 18 years old age groups*. Indian journal of medical sciences, 1997. **51**(5): p. 156-160.
15. Raouf, H.A., et al., *Frequency of palmaris longus absence and its association with other anatomical variations in the Egyptian population*. Clinical Anatomy, 2013. **26**(5): p. 572-577.
16. Sabouba, M., et al., *Prevalence of Absence of the Palmaris Longus Muscle among Medical Students of An-Najah National University: A Cross-Sectional Study from Palestine*. Palestinian Medical and Pharmaceutical Journal (Pal. Med. Pharm. J.), 2021. **7**(1): p. 77-84.
17. Sater, M.S., A.S. Dharap, and M.F. Abu-Hijleh, *The prevalence of absence of the palmaris longus muscle in the Bahraini population*. Clinical Anatomy, 2010. **23**(8): p. 956-961.
18. Hussain, F.N. and T. Hasan, *Prevalence of congenital absence of Palmaris Longus tendon in young Jizani population of Saudi Arabia: A cross sectional study*. 2012.
19. JP, S., *On the variations of the palmaris longus muscle*. Anat Rec, 1909. **3**: p. 275-278.
20. Thompson, J., J. McBatts, and C.H. Danforth, *Hereditary and racial variation in the musculus palmaris longus*. American Journal of Physical Anthropology, 1921. **4**(2): p. 205-218.
21. SB, P., *The 'two-finger' sign: Clinical examination of palmaris longus tendon*. Br J Plast Surg, 2004. **57**: p. 184.
22. Tallia, A.F. and D.A. Cardone, *Diagnostic and therapeutic injection of the wrist and hand region*. American family physician, 2003. **67**(4): p. 745-750.
23. Ravi, N., et al., *Palmaris Longus Tendon Absence in Pre-Clinical Medical Students of Universiti Malaysia Sabah*. Borneo Journal of Medical Sciences (BJMS), 2020. **14**(1).
24. Venter, G., A.-N. Van Schoor, and M.C. Bosman, *Degenerative trends of the palmaris longus muscle in a South African population*. Clinical Anatomy, 2014. **27**(2): p. 222-226.
25. Thompson, N., B. Mockford, and G. Cran, *Absence of the palmaris longus muscle: a population study*. The Ulster medical journal, 2001. **70**(1): p. 22.
26. Kose, O., et al., *The prevalence of absence of the palmaris longus: a study in Turkish population*. Archives of Orthopaedic and Trauma Surgery, 2009. **129**: p. 609-611.
27. Morais, M., et al., *Prevalence of agenesis of the palmaris longus muscle in Brazil and its clinics correlation*. Journal of Morphological Sciences, 2017. **29**(4): p. 0-0.

28. Mbaka, G., et al., *The incidence of agenesis of Palmaris longus among the Yoruba tribe in Nigeria*. Nigerian Journal of Medical Rehabilitation, 2008: p. 11-14.
29. Gangata, H., *The clinical surface anatomy anomalies of the palmaris longus muscle in the Black African population of Zimbabwe and a proposed new testing technique*. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists, 2009. **22**(2): p. 230-235.
30. Abledu, J. and E. Offei, *Prevalence of agenesis of palmaris longus and its association with gender, body side, handedness and other anomalies of the forearm in a student population in Ghana*. Rawal Medical J, 2014. **39**(2): p. 203-207.
31. Mbaka, G.O. and A.B. Ejiwunmi, *Prevalence of palmaris longus absence—a study in the Yoruba population*. The Ulster medical journal, 2009. **78**(2): p. 90.
32. Berhe, T. and A. Bekele, *Agenesis of palmaris longus muscle among selected Ethiopian students*. Anatomy & Physiology: Current Research, 2014. **4**(2): p. 1-5.
33. Kapoor, S.K., et al., *Clinical relevance of palmaris longus agenesis: common anatomical aberration*. Anatomical science international, 2008. **83**: p. 45-48.
34. Roohi, S., et al., *A study on the absence of palmaris longus in a multiracial population*. Malaysian Orthopaedic Journal, 2007. **1**(1): p. 26-28.
35. Sebastin, S.J., A.Y. Lim, and H. Wong, *Clinical assessment of absence of the palmaris longus and its association with other anatomical anomalies—a Chinese population study*. Annals-academy of Medicine Singapore, 2006. **35**(4): p. 249.
36. Agarwal, P., *Absence of the palmaris longus tendon in Indian population*. Indian journal of orthopaedics, 2010. **44**: p. 212-215.
37. Alves, N., D. Ramírez, and N.F. Deana, *Study of frequency of the palmaris longus muscle in Chilean subjects*. International Journal of Morphology, 2011. **29**(2): p. 485-489.
38. Erić, M., et al., *Prevalence of the palmaris longus through clinical evaluation*. Surgical and radiologic anatomy, 2010. **32**: p. 357-361.
39. Sankar, K.D., P.S. Bhanu, and S.P. John, *Incidence of agenesis of palmaris longus in the Andhra population of India*. Indian Journal of Plastic Surgery, 2011. **44**(01): p. 134-138.