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ORIGINAL STUDY

How often absence of palmaris longus and functional deficiency of flexor digitorum superficialis occurs ?

Nikola Vučinić, Mirela Erić, Mirjana Savić

From the Department of Anatomy, Faculty of Medicine, University of Novi Sad, Serbia

This study was designed to find a possible correlation between the presence of the palmaris longus and function of the fifth flexor digitorum superficialis. We examined 300 participants to assess the absence of palmaris longus and flexor digitorum superficialis function by several clinical tests. Overall absence of palmaris longus, was seen in 157 participants (52.3%). Overall deficiency of flexor digitorum superficialis was noted in 100 participants (33.3%). In 15 participants (5%) we noted bilateral absence of palmaris longus and flexor digitorum superficialis deficiency. Five participants (1.7%) had unilateral absence of palmaris longus and flexor digitorum superficialis deficiency on the same, left or right hand. Bilaterally presence of these muscles we noted in 95 participants (31.7%). We believe that there is no connection between absent palmaris longus and absent function of flexor digitorum superficialis. We found a much higher prevalence of muscles absence individually and jointly than in other studies.

Keywords : forearm ; muscles, skeletal ; palmaris longus muscle ; flexor digitorum superficialis ; absence.

INTRODUCTION

Palmaris longus (PL) is a slender, fusiform muscle medial to flexor carpi radialis (*7*). PL is one of the most variable and most superficial flexor muscles of the forearm. It is well known that there is a wide variation in the reported prevalence of PL absence in different ethnic groups (*2*,*4*,*8*,*13*). Many authors have reported the incidence of agenesis to be higher on the left side (*8*,*9*,*16*,*18*). There are controversial findings in the literature regarding the symmetry of muscle absence and distribution of agenesis between genders. Some authors have reported the incidence of agenesis to be higher in females (*2*,*8*,*21*), while others have reported higher incidence of agenesis in males (*1*,*6*,*23*). Understanding of its variations is useful as it is often used as tendon graft and for tendon transfer as well as in other reconstructive procedures. It is a weak flexor of the wrist. It is believed that the muscle once existed as a flexor of proximal phalanges with its tendon lying in the palm superficial to the flexor digitorum superficialis (FDS) and splitting around to be attached to the proximal phalanges. Studies have attempted to

■ Nikola Vučinić[1], MD.
■ Mirela Erić[1].
■ Mirjana Savić[2].
[1]*Department of Anatomy, Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia*.
[2]*Department of Physical Medicine and Rehabilitation, University of Novi Sad, Clinical Center of Vojvodina, Novi Sad, Serbia*.
Correspondence : Nikola Vučinić, Department of Anatomy, Faculty of Medicine, University of Novi Sad, Hajduk Veljkova 3, 21000 Novi Sad, Serbia.
E-mail : nikolavucinic87@gmail.com

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correlate absence of palmaris longus with other anatomical anomalies (*1*,*21*).

Flexor digitorum superficialis is located medial and deep to the PL and flexor carpi ulnaris. FDS is one of the largest superficialis flexor muscles of the forearm. FDS is an extrinsic muscle that flexes the proximal interphalangeal joints (PIPJ) and indirectly flexes the metacarpophalangeal joints of the hand. There is variation in the flexor digitorum superficialis to the fifth digit. The absence of the FDS may influence clinical examination in injured hands (*10*).

Considering that PL and FDS have the same embryological origin, the same innervation, similar functions, belong to the same muscle lodge and that are highly variable in existence and function, there is the possibility that their absence is associated.

We examined our population to assess FDS function to the little finger and the incidence of palmaris longus absence.

MATERIALS AND METHODS

The presence or absence of the PL and FDS tendons was clinically determined in 300 participants (150 males and 150 females), in Caucasian population, using several tests. Individuals with the history of injury, disease or abnormality of the upper limb, which would preclude examination for the presence of the PL tendon and the FDS to the little finger, were excluded from the study. The participants' age ranged from 18 to 66, mean age 19.6 years.

The examination was carried out in two parts. The first part of the examination assessed the presence of the PL. The presence or absence of the PL tendon was recorded on both sides. The participant was initially asked to do the Standard test (Schaeffer's test) for the assessment of the PL tendon (Fig. 1). If the tendon was not visualised or palpable, four additional tests were done to confirm the absence. A single examiner checked all participants. The following tests were used :

- Standard test (Schaeffer's test) : the participant was made to steady their forearm at 90 degrees and asked to oppose the thumb to the little finger with the wrist partially flexed (*18*).
- Thompson's test : the participant is asked to make a fist, then flex the wrist and finally the thumb is opposed and flexed over the fingers (*22*).
- Mishra's test I : the metacarpophalangeal joints of all fingers are passively hyperextended by the examiner and the participant is asked to actively flex the wrist (*11*).
- Mishra's test II : the participant is asked to abduct the thumb against resistance with the wrist in slight palmar flexion (*11*).
- Pushpakumar's "two-finger sign" method : the participant is asked to fully extend the index and middle fingers, the wrist and other fingers are flexed, and finally the thumb is fully opposed and flexed (*15*).

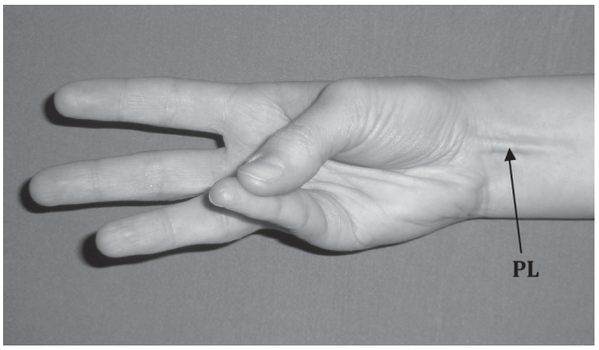

Fig. 1. — Standard test (Schaeffer's test) : PL on the right hand.

Finally, the wrists of every participant were examined by using the palpation during each of five previous tests, to insure the reliability of obtained results. The results acquired through the palpation were considered as the results of maximal accuracy.

The second part of the examination assessed the functional ability of the superficialis tendon to flex the proximal interphalangeal joint (PIPJ) of little finger. FDS function in the little finger was assessed by Standard test and divided into independent (Fig. 2) or absent function (Fig. 3). Independent function was defined as the ability to flex the PIPJ of the little finger > 90 degrees with the PIPJ of the other fingers of the same hand extended by covered with the fingers of the other hand. Absent function was the inability to flex the PIPJ > 90 degrees with the PIPJ of the other fingers of the same hand extended by covered with the fingers of the other hand. When it was unable for sure to determine FDS function, after Standard test were applied Present test and test by blocking the finger metacarpophalangeal joint (MCPJ). In Present test, the participant is asked to press the finger tip pulp of all the fingers together against the proximal part of the palm. If the FDS is acting, the distal interphalangeal joint (DIPJ) remains in a position of extension to hyperextension while the MCPJ and PIPJ are fully flexed. Flexion of DIPJ is taken as absence of FDS action (*12*). In

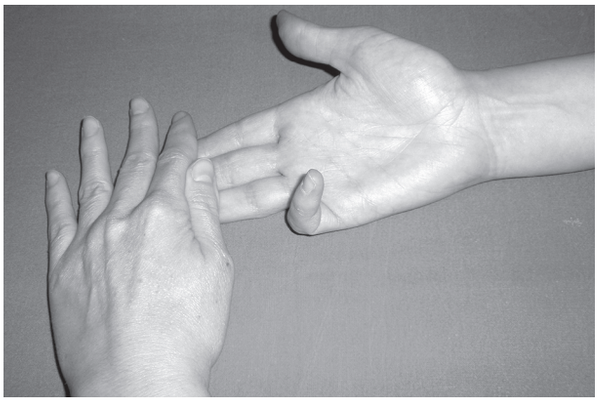

Fig. 2. — Standard test : independent function of FDS on the right hand.

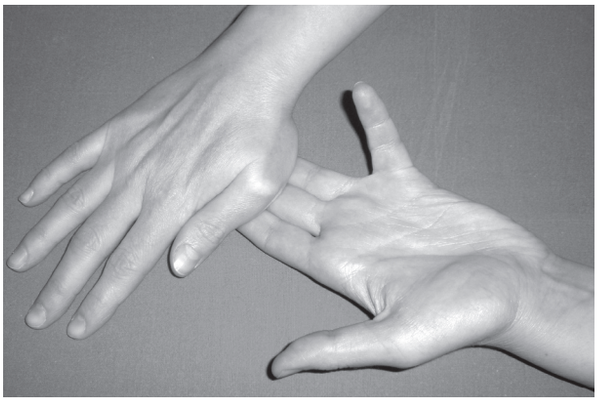

Fig. 3. — Standard test : absent function of FDS on the left hand.

test by blocking the MCPJ, participant was also asked to flex the PIPJ. To block the MCPJ, hold the proximal phalanx in extension just distal to the MCPJ, so that the MCPJ is unable to bend when the patient tries to flex the finger (*19*).

We used only three tests for examination of flexor digitorum superficialis functional deficiency. If the FDS function was demonstrated using any of the tests, the subject was deemed to have FDS function. Absence of FDS function on all the tests was required to declare the subject FDS functional deficient.

This study was approved by Ethics Committee of Faculty of Medicine in Novi Sad.

RESULTS

In general population, unilateral absence of the palmaris longus muscle was recorded in 69 (23%) and bilateral absence in 88 (29.3%) participants. It was absent on the right side in 32 (10.7%) and on the left side in 37 (12.3%) participants. The overall absence of palmaris longus (unilateral and bilateral) was 52.3%. These results are shown in Table I. If PL was absent in one hand, the probability of absence in the opposite hand was 0.56. If PL was present, the probability of absence in the other hand was 0.32.

In the same population, unilateral deficiency of FDS to the little finger was seen in 48 (16%) and bilateral deficiency in 52 (17.3%) participants. It was absent on the right side in 21 (7%) and on the left side in 27 (9%) participants. The overall absence of flexor digitorum superficialis (unilateral and bilateral) was 33.3%. The absence of the FDS is presented in Table II. If FDS function was absent in one little finger, the probability of absence in the opposite hand was 0.52. If superficial function was present, the probability of absence in the other little finger was 0.19.

From the obtained data it was found that PL was more frequent absent (unilaterally and bilaterally) in men than women, 92 (61.3%) vs. 65 (43.3%) participants. Regarding to the absence of flexor digitorum superficialis function to the little finger (unilaterally and bilaterally) it was more frequent in women than men, 60 (40%) vs. 40 (26.7%) participants. The results are presented in Table I and Table II.

We compared the deficiency of the FDS in the little finger with the absence of the PL tendon, and we found that difference was statistically significant in general population ($X^2 = 22.11, p < 0.001$), while gender distribution of the FDS deficiency with PL absence was statistically significant in males ($X^2 = 57.74, p < 0.001$) and statistically was not significant in females ($X^2 = 0.34, p > 0.05$).

In relation to the hand dominance, we found 23 left-handed individuals (7.7%). Differences between the left and right-handed individuals as for the absence or presence of these two muscles were not significant.

We did not encounter any other congenital anomalies in the study group.

Table I. — Palmaris longus absence according to gender and limb laterality

Palmaris longus tendon	No. of examined individuals	%	Men (*n*)	%	Women (*n*)	%
Bilateral present	143	47.7	58	38.7	85	56.7
Right absence	32	10.7	16	10.7	16	10.7
Left absence	37	12.3	23	15.3	14	9.3
Bilateral absence	88	29.3	53	35.3	35	23.3
Total	300	100	150	100	150	100

DISCUSSION

Muscular variations of the flexor compartment of forearm are usual and could result in multiple clinical conditions limiting the functions of forearm and hand. Palmaris longus is one of the most variable muscles in the body. It may be agenetic, double, tendinous, split, incomplete, digastric or exhibit anomalous insertions. It has been suggested that palmaris longus is a phylogenetically degenerate metacarpophalangeal joint flexor (*8*,*9*,*20*,*26*).

One advantage of the PL tendon is that it protects the median nerve which passes deep into in. In the absence of the PL tendon, the most superficial structure in the wrist is median nerve, which is at risk of injury during trauma and surgical incisions (*1*). PL muscle is very useful for its role in orthopedic and plastic surgeries. Its presence in 70-85% population and its superficial location makes it the most common donor material for tendon and joint reconstructive surgeries. PL is completely developed at birth while fascia lata, which is also used for reconstructive surgeries, is not so well developed at that age. Surgeons should acquaint themselves with prevalence in their areas of practice (*1*).

The palmaris longus agenesis among various races and ethnic groups is variable (*13*), from 0.6% in the Korean population to 63.9% in the Turkish population (*2*,*4*). The absence of palmaris longus muscle is strictly hereditary characteristic. Palmaris longus muscle is an inherited autosomal dominant trait. The absence of palmaris longus muscle is probably connected with a single dominant gene (which shows incomplete penetration and variable expressivity), and/or absence is due to the effects of mutations (*27*).

Erić *et al* in study which includes 800 participants, were found that unilateral absence of the palmaris longus was record in 173 (21.6%) and bilateral in 127 (15.9%) study participants. According to body side, right-sided absence of palmaris longus was found in 69 (8.6%) and left-sided in 104 (13%) participants. It has been suggested that this tendon is rapidly disappearing in humans (*8*).

Absence of flexor digitorum superficialis function in the little finger is a relatively common congenital anomaly that can complicate assessment of little finger injuries. Townley *et al* reviewed the prevalence of flexor digitorum superficialis absence of superficialis function, unilateral and bilateral, in

Table II. — Flexor digitorum superficialis functional deficiency according to gender and limb laterality

Flexor digitorum superficialis	No. of examined individuals	%	Men (*n*)	%	Women (*n*)	%
Bilateral present	200	66.7	110	73.3	90	60
Right absence	21	7	13	8.7	8	5.3
Left absence	27	9	13	8.7	14	9.3
Bilateral absence	52	17.3	14	9.3	38	25.4
Total	300	100	150	100	150	100

Table III. — Published series documenting absence of PL and FDS

Authors	Year	Participants	Ages (years)	Overall absence PL %	Overall deficiency FDS %
Our study	2014	300	19.6	52.3	33.3
Agarwal (*1*)	2010	385	20-24	20.2	16.1
Sandeep *et al* (*18*)	2006	329	43.4	4.6	6.4
Thompson *et al* (*24*)	2002	300	18-40	25	3

the published literature. In appropriate studies (cadaveric studies were excluded) gathering 1352 people, the anomaly was unilateral in 92 individuals (6.8%) and bilateral in 81 (6.0%). Also, they were founded that absence of little finger superficialis function in one hand is therefore not a reliable indicator of this function in the opposite hand (*25*).

A separate flexor digitorum superficialis tendon for the index finger has been identified (*5*).

Some studies mention that if a patient has a PL tendon, then there is the high chance of Dupuytren's disease developing in that hand (*1*,*14*). Also, some other studies recommended that the presence of the PL tendon should potentially increase the pressure within the carpal tunnel it can be suspected that the presence of this tendon versus its absence can be associated factor in the development of carpal tunnel syndrome (CTS). Theoretically the presence and function of FDS tendon, as well, should increase pressure on the median nerve (*17*).

However, Saied and Karamoozian found that the absence of a functional fifth FDS and a PL tendon are risk factors for developing CTS (*17*). This study showed that the absence of the PL tendon and fifth FDS function, independently and in combination, is more frequent in patients with CTS. In the group with CTS, 16/60 hands (26.7%) did not have a PL tendon and 18/60 hands (30%) were lacking fifth FDS function. Eight hands had neither of these (12.3%) and 34 hands had both (56.7%). In the group without CTS, 27/180 hands (15%) lacked the PL and 25/180 (13.9%) lacked a functional fifth FDS. Eight hands had neither of these (4.5%) and 136 hands had both (75.6%).

In their study of 300 patients, Thompson *et al* (*24*) found 10 (3%) participants with absolute superficialis deficiency to the little finger (unilaterally and bilaterally). The overall absence of PL (unilaterally and bilaterally) was seen in 71 participants (25%). In this study, only two patients had concomitant absence of the PL and the FDS to the little finger.

In the sample of 385 Indian men and women, the overall unilateral absence of the PL tendon was 16.9% and the bilateral absence was in 3.3%. The overall prevalence of the weak FDS in the little finger irrespective of the presence or absence of the PL tendon in this study was 16.1% (*1*).

The overall prevalence of absence of the PL, in the Chinese population study that included 329 Chinese men and women, was 4.6%. Also, deficiency of FDS to the little finger was seen in 6.4% (*18*).

In our study, overall prevalence of absent PL (unilateral and bilateral) was 52.3%. The overall prevalence of weak FDS in the little finger in our study was 33.3%. The prevalence of the unilateral and bilateral absence of the PL tendon and prevalence of weak FDS in the little finger in our population is much higher than the others studies. This high prevalence of lack function of the fifth finger flexion may indicate a gradual regression fifth tendon of FDS, due to insufficient amounts of the fifth finger during flexion of the fingers. That shows four studies with approximately same number of subjects (Table III). In the present study, we further confirmed earlier claims that PL tendon is rapidly disappearing in humans (*8*).

On the other side, the overall prevalence of associated absent FDS function unilateral or bilateral with absent PL unilateral or bilateral on the same, left or right hands, in our study was 6.7%. As well, 31.7% had bilaterally presence both of these muscles. Lack of association between these two muscles is also the highest in our study.

Statistically difference between FDS deficiency in the little finger and PL tendon absence in general population was significant ($p < 0.001$), while gender distribution of the FDS deficiency and PL absence was statistically significant in males ($p < 0.001$), on the other hand statistically was not significant in females.

Validation of used clinical tests, in the examination of PL presence in our study, was performed in comparing to palpation. Effectiveness of different tests were : Thompson's test- 83.5%, Standard test (Schaeffer's test)- 81%, Pushpakumar's "two-finger sign" method- 91%, Mishra's test I- 78% and Mishra's test II- 87.5%. Borkach and Rákoczi in study of PL in 1839 Hungarians, showed these results of effectiveness : Thompson's test- 83.5%, Standard test (Schaeffer's test)- 88.7%, Pushpakumar's "two-finger sign" method- 84.6%, Mishra's test I- 96.3% and Mishra's test II- 86.7% (*3*). According to the results of our study, the most reliable is the Pushpakumar's "two-finger sign" method and in Hungarian study the Mishra's test I showed the highest efficiency. Although there is no congruency in the previous order, the most reliable test between these studies, it is interesting that effectiveness of Thompson's test was identical between the two studies.

We consider that there is no connection between absent function of flexor digitorum superficialis to the little finger and absent palmaris longus as well as present function of FDS to the little finger and present PL. In this conclusion we cite the fact that less than half (38.4%) of the participants had associated the absence or presence of these two muscles in both forearms. But, we have established that association with the absence or presence of these two muscles in both forearms, are much more frequent than in other studies.

It has been postulated that an absence of the plantaris may be associated with the agenesis of the PL tendon, but we did not examine that possible association.

Possible limitation of these clinical studies is the difficulty in assessment of all variations of PL muscle depending solely on a physical examination. Although rarely seen, these variations may lead to misinterpretation of an existing muscle as absent. Ultrasonography or MRI would confirm these variations precisely, but it is neither cost-effective nor time sparing (*8*). Muscle ultrasonography is a convenient technique to visualize muscle tissue as it is non-invasive and real-time. The use of ultrasonography is recommended in certain pathological conditions, such as carpal tunnel syndrome or other neuromuscular disorders (muscle atrophy and intramuscular fibrosis and fatty infiltration can be visualized with ultrasonography). Usually, ultrasonography has not found the routine use of either a reconstructive surgeons in preoperative preparation of palmaris longus tendon as well as in routine examination of intact structure and function (*7*). Most surgeons determine the existence of the palmaris longus simply by performing previously described clinical tests.

The function of the hand is a very complex and human hand is in the center of daily life activities. Because of those injuries of hand and flexor tendons are very common. PL muscle is very useful for its role in orthopedic and plastic surgeries and it protects the median nerve which passes deep into it. Its superficial location makes it the most common donor material (tendon graft) for flexor tendon and joint reconstructive surgeries. The absence of the FDS may influence clinical examination of injured hands in the first order it complicates assessment of little finger injuries. In some musicians absence or functional deficiency of this muscle may limit movements of the little finger.

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