CLINICAL ASSESSMENT OF ABSENCE OF PALMARIS LONGUS MUSCLE AND ITS ASSOCIATION WITH GENDER, BODY SIDES, HANDEDNESS AND OTHER NEIGHBORING ANOMALIES IN A POPULATION OF CENTRAL INDIA

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ABSTRACT
The palmaris longus (PL) is a vestigial or degenerating superficial muscle in the anterior compartment of forearm. It is variable in its structure, attachments and presence or absence in different individuals in various populations and even in one population among individuals. It is well known that individuals may have unilateral or bilateral absence of PL. The aims of this study were to determine the incidence of absence of PL and its association with gender, body sides, handedness and other neighboring anomalies like the absence of flexor digitorum superficialis (FDS) muscle to little finger, the incomplete superficial palmar arch (SPA) etc. in a population of central India; and to correlate the same with the other related studies. We examined 400 Caucasian subjects (200males and 200 females of a population of central India) aged 18-55 years. Total 65 (16.25%) subjects had overall absence of PL, out of which 25 (6.25%) presented bilateral absence and 40 (10%) presented unilateral absence so statistically unilateral absence was little more common than bilateral absence. Overall absence and unilateral absence of PL were little more common in males (M:8.5%,F:7.75% and M:5.75%,F:4.25% respectively) whereas bilateral absence was little more common in females (F:3.5%,M:2.75) however these associations with gender were not statistically significant. In unilateral PL absence, the right and the left sides were more or less equally affected (RT: 5.25%, LT: 4.75%) and no statistical significance was evident for this association with body sides. Out of 65 subjects with absence of PL only 5 were left handed and rest right handed so this association with handedness was also statistically insignificant. No correlation was evident between PL absence and other neighboring anomalies like absence of FDS to little finger, incomplete SPA etc. So the present study concluded with (i) The unilateral absence is statistically little more common than the bilateral absence (ii) There is no statistical association between the PL absence and gender, body sides, handedness and other neighboring anomalies like absence of FDS to little finger, incomplete SPA etc. in a population of central India.

Key words: Palmaris longus, absence, clinical assessment, Handedness.

INTRODUCTION:
The PL is one of the five muscles in the superficial group of the front of forearm, lying medial to the flexor carpi radialis. Its origin is from the common flexor origin and insertion is into the distal half of flexor retinaculum and the apex of palmar aponeurosis It is supplied by the median nerve and its action is flexion of the hand at the wrist & in making the palmar aponeurosis tense. It is well known that individuals may have unilateral or bilateral absence of PL, a structure often used in reconstructive plastic surgery mainly in the setting of tendon grafting, although it has also been used for a wide variety of procedures including lip augmentation, ptosis correction and facial palsy management[1,2,3,4]. The PL is a degenerating muscle as it has a short belly and a long tendon. It is absent in 10% subjects. The palmar aponeurosis represents the distal part of tendon of PL and is an evidence of retrogression of the muscle {cf. the plantaris in the leg}[5]. It has been described as a phylogenetically degenerate metacarpophalangeal joint flexor[6,7]. The PL muscle may be tendinous above and muscular below; or may be muscular in the center with a tendon above and below; or may present two muscular bundles with a central tendon or finally may consist solely of a tendinous band. The muscle may be double. An inverse (updown) palmaris longus muscle was present in a cadaver on both sides[6,8]. Often absent on one or both sides, the muscle is very variable[9,10]. PL is fully developed at birth[11]. A reversed PL may cause a compartment syndrome with pain & edema in the wrist area, the carpal tunnel syndrome and Guyon's syndrome. The overuse of the reversed PL can lead to the muscle's

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local hypertrophy[12]. Rarely is the PL double, whereas the three-headed reversed PL is mentioned in the literature as a surgical finding in a patient 36 year old woman who suffered from edema and pain in the wrist[13]. In a 73 years old female cadaver the PL was tendinous in its upper part and muscular in its lower part with triple muscle belly, thus finding was characterized as "three-headed reversed PL[14]. These described variations are important to the hand surgeons and those testing PL tendon at the wrist.

The prevalence of absence of the PL has been extensively studied following the first report of its absence in 1559 by Colombos in De Re Anatomica Libri[15,16]. It is well known that there is a wide variation in the reported prevalence of PL absence in different ethnic groups[9,17]. PL is present in about 70-85% population[18]. According to the literatures the PL is a variable muscle, absent in about 16% of Caucasians and less frequently absent in other populations. Some authors suggest that apart from its ethnic variations, its absence is more common in women, bilateral absence is more common, and unilateral absence more frequent on the left side[19,20]. Some have attempted to correlate the absence of the PL with other anatomical anomalies like an anomalous SPA, an absence of the plantaris etc.[18,21]). A clinical study has even attempted to explore the relationship between the functional absence of the FDS to the little finger and the absence of the PL[22]. Most papers attempting to correlate the relationship of the PL with other anatomic structures have been carried out in Caucasian subjects.

The prevalence of palmaris longus agenesis was found to be 17.2% (8% bilateral and 9.2% unilateral). The prevalence was significantly more common on the left side. Male subjects had a greater likelihood of unilateral agenesis, while female subjects were more likely to have bilateral agenesis[23]. The prevalence of an absent PL in the Chinese was 4.6%, which is much lower than what is commonly mentioned in the literature. There was also no relationship between the absence of PL and the body side, gender and whether the absence is unilateral or bilateral. The prevalence of absence of FDS to the little finger in the Chinese was 6.4%. There seemed to be no association between the absence of the PL and other anatomical structures like the FDS to the little finger, the plantaris, the SPA etc. Further study is needed to confirm this[24a]. In Chinese men and women the palmaris longus overall absence was 4.6% with unilateral in 3.3% and bilateral in 1.2%. There was no significant difference in its absence with regard to the body side or the sex. Our literature review revealed a low prevalence of absence in Asian, Black and Native American populations and a much higher prevalence of absence in Caucasian populations. It is clear that a standard prevalence of absence of the palmaris longus cannot be applied to all populations[24b]. The overall prevalence of absence of PL (unilateral or bilateral) was 26.6% in Turkish population. The absence of PL in women was statistically more common than men. Bilateral absence of PL was statistically frequent than unilateral absence. The prevalence of absence of PL was statistically similar between the body sides[25]. Previous studies showed differences in incidence of agenesis of PL in different races as Ugandans 1.02%, Zimbabweans 1.5%, Congolese 3.0%, Turks 26.6%, Japanese 3.4%, Chinese 2.2%, Germans 20.4%, Americans 12.8%, and among Indians 17.2%. Amongst Nigerians, the overall agenesis of PL is 0.17% with unilateral more frequent and males more involved[26]. In contrast, another study in Nigerians states that 31.25% subjects lacked PL on either of the forearms, 12.5% showed unilateral absence and 18.75% showed bilateral absence[27].

MATERIAL AND METHOD:

In present study 400 central Indian subjects (200males & 200 females) aged between 18 to 50 years were randomly selected by the principal author and examined. The individuals with a history of injury or acquired abnormality of the upper limbs were excluded from this study. After recording the age, sex and handedness of each subject, he or she was examined on both sides for the presence or absence of the PL at the wrist, the FDS to the little finger, the incomplete SPA and finally for any other anomalies in hand or forearm. Relationships between unilateral/bilateral absences of the muscles and sex, body sides, handedness and other neighboring anomalies were analysed.

To test PL, Standard/Schaeffer's and other tests were applied according to Sebastin et al[24a]. In Standard test the subject was asked to oppose the thumb to the little finger and then flex the wrist (Fig.1&2). When the test was negative to visualize PL tendon at the wrist then other tests were applied as follows:

Thompson's test: The subject is asked to make a fist then flex the wrist and finally oppose and flex the thumb over the fingers.

Mishra's test I: The metacarpophalangeal joints of all

fingers are passively hyperextended by the examiner and the subject is asked to actively flex the wrist.

Mishra's test II: The subject is asked to abduct the thumb against resistance with the wrist in slight palmar flexion.

Pushpakumar's "two-finger sign" method: The subject is asked to fully extend the index and middle finger, the wrist and other fingers are flexed and finally the thumb is fully opposed and flexed.

In our study one new test we found equally good to visualize PL tendon when Standard/Schaeffer's test failed. Here subject was asked to make tight fist with slightly flexed wrist and then to abduct & extend the thumb (Fig.3). If PL is present then it definitely presents its tendon at the wrist. The prevalence of absence of the PL (unilateral or bilateral) was presented with a 99% confidence as its variations may obscure the muscle and all tests may be negative.

To test the FDS to little finger, Standard and Modified tests were applied according to Austin et al[36]. First full and free active range of movement of the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints of all fingers of both hands was confirmed. In Standard FDS test, all the fingers except the little finger were held out in extension. The wrist was kept in full supination and neutral extension. The subject was then asked to flex the little finger (Fig.4). If PIP joint flexion occurred with no DIP joint flexion, this was interpreted as showing independent FDS function and recorded as FDS-independent. If PIP joint flexion did not occur or if PIP joint flexion occurred only in conjunction with DIP joint flexion, the subject underwent the modified FDS test. In the modified FDS test, all fingers except the little and ring fingers were held out in extension. The wrist was kept in supination and neutral extension. The subject was then asked to flex the little finger. If the little finger PIP joint flexion occurred with no DIP joint flexion (when the ring finger was also allowed to flex), this was interpreted as showing common FDS function and recorded as FDS-common. If the little finger PIP joint flexion did not occur, or if PIP joint flexion occurred only in conjunction with DIP joint flexion (even with ring finger flexion), this was believed to be evidence of no FDS function and recorded as FDS absent.

To test the completeness of SPA, Allen's test was applied. The subject was asked to clench his/her fist several times while examiner occludes the radial and ulnar artery at the wrist (Fig.5). Then subject extends their fingers, palm up, which should show a "blanched" hand. The operator then releases the pressure on the ulnar artery and the hand is observed for "blushing". If the color of the hand does not return in 5-10 seconds the Allen test is considered positive, suggestive of incomplete SPA.

Finally the hand and forearm were examined for any other anomalies present.

The association between the absence of PL and sex, body sides, hand dominance and other neighboring anomalies like absence of FDS to the little finger, incomplete (SPA) etc. was assessed using Chi-square or Fisher's exact tests. Statistical significance was set at $P < 0.05$.

OBSERVATIONS:

Average age of subjects was 36 years (range 18-55years). Total 65 (16.25%) subjects had overall absence of PL, out of which 25 (6.25%) presented bilateral absence and 40 (10%) presented unilateral absence so statistically unilateral absence was little more common than bilateral absence. Overall absence and unilateral absence of PL were little more common in males (M:8.5%,F:7.75% and M:5.75%,F:4.25% respectively) whereas bilateral absence was little more common in females (F:3.5%,M:2.75) however these associations with gender were not statistically significant. In unilateral PL absence, the right and the left sides were more or less equally affected (RT: 5.25%, LT: 4.75%). Unilateral absence of PL on right side is more common in males (M:3.75%,F:1.5%) and on left side is more common in females (F:2.75%,M:2%) however no statistical significance was evident for this association with body sides and gender.

Table 1 : Result after examination of 400 subjects for absence of PL

Muscle absence	Total	Males	Females	Right side	Left side
Overall	65	3	31	#	#
Bilateral	25	11	14	#	#
Unilateral	40	23	17	21	19
Unilateral right side	21	15	6	21	#
Unilateral left side	19	8	11	#	19

In 400 subjects examined, only 16 subjects (4%) were left handed and rest were right handed. Out of 65 subjects found with absence of PL, only 5 were left handed and rest were right handed, so this association with handedness was also statistically insignificant.

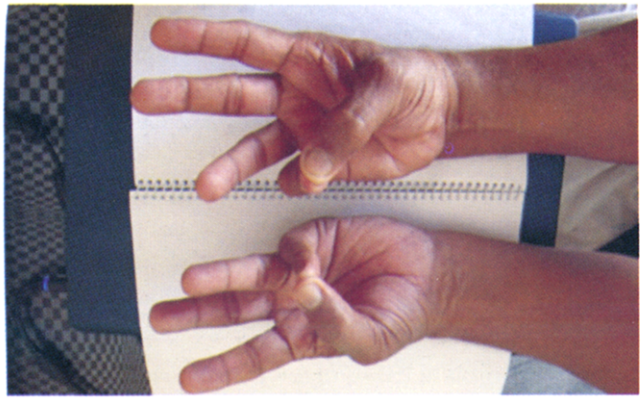

Fig.1: Standard Test: PL absent on left hand

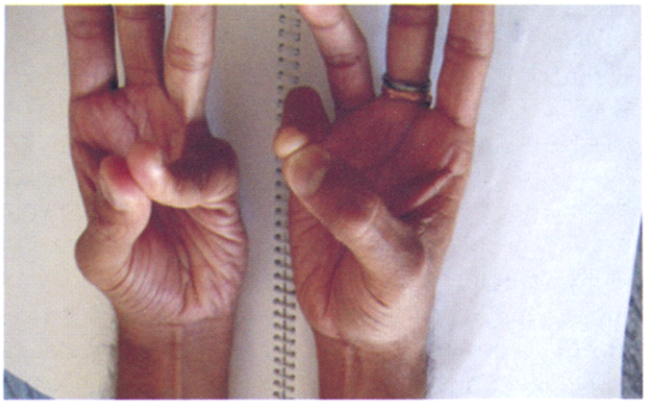

Fig.2: PL presence bilaterally

Fig.3: New test for PL

Fig.4: Standard test for FDS to little finger

Fig.5: Allen's test

Fig.6: 4 palmar creases on left little finger

Out of 400 subjects examined for FDS to little finger, only 1 male subject was found with absence of FDS to little finger on both sides with concomitant absence of PL on his right side.

Out of 400 subjects examined by Allen's test, only 2 subjects 1 male and 1 female were found to have incomplete SPA on their both sides with normal presence of PL and FDS in them.

Out of 400 subjects examined for other neighboring anomalies in hand & forearm, only one female subject presented one congenital anomaly of 4 palmar creases in her left little finger (Fig.6) in place of normal 3 palmar creases with concomitant unilateral absence of PL on her left side. On her right little finger normal 3 palmar creases were present. X-ray of her hands presented no bony or other abnormalities.

No correlation could be evident between PL absence and other neighboring anomalies like absence of FDS to little finger, incomplete SPA and anomalous digital palmar creases.

DISCUSSION:

Tendon grafts are frequently needed in reconstructive surgery on the hand. Many surgeons agree that the PL tendon is first choice as a donor tendon because it fulfills the necessary requirement of length, diameter and availability and can be used without producing functional deformity[28]. The PL tendon is often considered the ideal donor for tendon grafts for replacement of long flexors of the fingers and the thumb[29]. The superficial position of PL and its vestigial nature are other positive points for its choice as a tendon donor.

In vertebrates, PL is found only in mammals and is best developed in those where the forelimb is used for ambulation and is variably absent in higher apes such as chimpanzees and gorillas[30]. The PL is always present in the orangutan. In humans the absence of PL appears to be hereditary but its genetic transmission is not clear[18]. PL is often described as one of the most variable muscles in the human body and is classified as a phylogenetically retrogressive muscle i.e. a short belly with a long tendon[5,6,31]. The muscle may have a proximal tendon or be reduced to a tendinous strand. It may be digastric or reduplicated[6,8]. The authors have also noticed these findings during dissecting the cadavers for teaching to undergraduates and postgraduates in the form of their short bellies and long tendons and their absence unilaterally or bilaterally. We have seen the PL partially covering the median nerve and varying in size from a thin slip of tendon to a wide, flat tendon. Occasionally the muscle belly was found extending to the wrist and compressing the median nerve. Muscle testing may cause the FDS and flexor carpi radialis to bulge into subcutaneous area of the wrist and simulate the PL. Its tendon can be easily seen or palpated in the middle of lower part of ventral aspect of forearm by making the fist with slightly flexed wrist and extended and abducted thumb. The tendon if present will be visible usually midway between the ulnar and radial borders of the wrist.

Most standard textbooks of hand surgery quote a prevalence of absence of PL around 15% in Caucasian[18,32,33]. Wehbe MA and Mawr Bryn (18) reported 70-85% presence of PL muscle. Some authors suggest that apart from its ethnic variations, its absence is more common in women, bilateral absence is more common, and that unilateral absence occurs more frequently on the left side[19]. The higher percentage for bilateral absence of PL against unilateral incidence was also recorded[20]. From the results of numerous previous studies it has been reported that bilateral absence of PL occurs in 8-16% individuals and unilateral in 4-14%[30]. The prevalence of PL agenesis was found to be 17.2% (8% bilateral and 9.2% unilateral). The prevalence was significantly more common on the left side. Male subjects had a greater likelihood of unilateral agenesis, while female subjects were more likely to have bilateral agenesis[23]. Overall prevalence of absence of PL in the Chinese population was 4.6% with bilateral 1.2% and unilateral 3.3%[24]. The overall prevalence of absence of PL (unilateral or bilateral) was 26.6% in Turkish population. Here the absence of PL in women was statistically more common than men. Bilateral absence of PL was statistically frequent than unilateral absence. The prevalence of absence of PL was statistically similar between the body sides[25]. In Nigerians the overall agenesis of PL was only 0.17% with unilateral more frequent and males more involved[26]. Among Nigerian population, 31.25% subjects lacked PL, out of which 12.5% showed unilateral absence and 18.75% showed bilateral absence[27] The right side was affected more commonly in unilateral absence but no statistically significant correlation was found between PL absence and gender or body side[16]. Previous studies have conflicted with regard to the incidence of PL absence in relation to body side and gender[18-20].

Our study, like most of the previous studies, reflects the incidence of PL absence in Caucasian individuals. The overall prevalence of PL absence was 16.25% subjects which compared favourably the figure indicated above in Caucasians by many authors like Kapoor et al[23], Wehbe MA and Mawr Bryn[18], Hentz VR and Chase RA[32] and Zancolli EA and Cozzi EP[33] but was not in accordance with figures for Chinese (4.6%) by Sebastin et al[24a,b], Turkish (26.6%) by Ozkan Kose et al[25], Nigerian (31.25%) by Oladipo GS et al[26]) and Kayode AO et al[27]. Racial variations were however well recognized. Our figure for bilateral absence of 6.25% was little less than what was reported in Caucasians by Schaeffer[19] and Vanderhooft[30] but figure for unilateral absence 10% had favourable symmetry with them.

We found the unilateral PL absence statistically little more common than bilateral (10% & 6.25%), which was not in accordance with the finding of Vanderhooft[30], Kapoor et al[23] and Reimann et al[20] but similar to findings by Thompson et al[16] and Oladipo et al[26].

Most studies like Schaeffer[19] indicate that in unilateral PL absence, the left side involvement is more common whereas some like Thompson NW et al[16] indicate more involvement of the right side and a few like Ozkan Kose et al[25] claim for equal involvement of both sides too. Our study found unilateral PL absence involvement more or less equal on both sides (Rt:5.25%,Lt:4.75%), which was against the claims for Schaeffer[19] and Thompson et al[16] but was similar with the finding by Ozkan Kose et al[25].

In present study male and female involvement in overall PL absence was more or less equal (M:8.5%,F:7.75%) however bilateral absence was little more common in females (F:3.5%,M:2.75) and unilateral absence was little more common in males (M:5.75%,F:4.25) but no statistical significance of these involvements could be evident. Our finding was in accordance with the claims by Thompson et al[16] and Kapoor et al[23] but was not in accordance with the finding of Schaeffer[19] and some others. There is disagreement in the literature regarding the symmetry of muscle absence and whether absence is more common in women. The discussion of this point is made difficult because most authors do not support their conclusions with statistical analysis of the data. The studies where statistical analysis was carried out failed to detect any association between the absence of PL and the side of the body or the sex. Our study showed the prevalence of PL absence more or less equal in gender statistically.

Out of 400 subjects examined only 16 subjects (4%) were left handed and rest were right handed. Out of 65 subjects with absence of PL only 5 were left handed, in which 3 were male having bilateral PL absence and two were female having unilateral left side PL absence. These differences were insignificant statistically and no correlation could be established between absence of PL and handedness of person. No literature is available regarding association between absence of PL and handedness of the Person.

Some authors have attempted to correlate the absence of the PL with other anatomical anomalies like tendon of FDS to little finger, an anomalous SPA, an absence of the plantaris, etc.[21,34]. The prevalence of absence of the FDS to the little finger was found to be around 15-21% in Caucasian populations[22,35,36]. The prevalence of absence of the FDS to the little finger was 6.4% in Chinese, but only 1 male patient with bilateral absence of the PL had a concomitant absence of the FDS to the right little finger so there was no correlation between the absences of the PL and the FDS to the little finger[24a]. In a study of 300 patients only 2 patients were found with concomitant absence of the PL and the FDS to the little finger[22]. In our study the prevalence of absence of the FDS to the little finger was 0.25% only, which was quite low when compared to the available figures just mentioned., Out of 200 males and 200 females only 1 male subject was found with absence of FDS to little finger on his both sides with concomitant absence of PL on his right side. So it appeared safe to conclude that there was no association between the functional absence of the FDS to little finger and unilateral or bilateral absence of the PL, irrespective of ethnic origins.

O'Sullivan E and Mitchell BS[21] found an association between the absence of the PL and the presence of an abnormal SPA. Out of the 47 cadaveric hands they examined, the PL was absent in 25 hands and of these 25 hands, the SPA was anomalous in 22 hands. On the other side Sebastin et al (24a) reported that out of the 15 subjects with an absent PL tendon only 1 subject (a female) had Allen's test positive suggestive of an incomplete SPA so they claimed no association between the absence of the PL and an incomplete SPA. However this could not be statistically verified as they did not perform an Allen's test on all subjects. In our study too where we examined all 400 subjects by Allen's test, only 2

subjects 1 male and 1 female presented the incomplete SPA bilaterally with normal presence of PL and FDS in them. So the prevalence of anomalous SPA in our study (0.5%) was quite low when compared with available figures and it confirmed no association between the PL absence and an incomplete SPA.

Finding of anomalous palmar creases (4 creases instead of normal 3 creases) in the left little finger in a female subject with concomitant absence of PL on her left side could not be correlated. On her right little finger normal 3 palmar creases were present and X-ray of hands presented no bony or other abnormalities. It seemed there was no relationship between this anomaly and absence of PL. No related report is available for its correlation.

It has been postulated that an absence of the plantaris may be associated with agenesis of the PL, however a review of literature showed 4 studies which specifically addressed this question and statistically analysed their data and failed to demonstrate any association between the absence of the PL and the plantaris[18,30,37,38]. This relationship we could not explore in this study.

CONCLUSION:

We examined 400 Caucasian subjects (200males and 200 females of population of central India) aged 18-55 years. Total 65 (16.25%) subjects had overall absence of PL, out of which 25 (6.25%) presented bilateral absence and 40 (10%) presented unilateral absence so statistically unilateral absence was little more common than bilateral absence. Overall absence and unilateral absence of PL were little more common in males (M:8.5%,F:7.75% and M:5.75%,F:4.25% respectively) whereas bilateral absence was little more common in females (F:3.5%,M:2.75) however these associations with gender were not statistically significant. In unilateral PL absence, the right and the left sides were more or less equally affected (RT: 5.25%, LT: 4.75%) and no statistical significance was evident for this association with body sides. Out of 65 subjects with absence of PL only 5 were left handed and rest right handed so this association with handedness was also statistically insignificant. No correlation could be evident between PL absence and other neighboring anomalies like absence of FDS to little finger, incomplete SPA etc. So the present study concluded with (i) The unilateral absence is statistically little more common than the bilateral absence (ii) There is no statistical association between the PL absence and gender, body sides, handedness and other neighboring anomalies like absence of FDS to little finger, incomplete SPA etc. in the studied population of central India.

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