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Original Article

Sensitivity and specificity assessment of four clinical tests for palmaris longus muscle by ultrasound

Zennure Adıgüzel Şahin[1], Mehmet Üzel[1], Fatma Güler Kahraman Yıldırım[1], Mahmut Ercan Tanyeli[1], Ahmet Ertaş[1], Deniz Palamar[2], Tuğçe Özekli Mısırlıoğlu[2], Kenan Akgün[2], Ahmet Dirican[3]

[1]Department of Anatomy, İstanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty, İstanbul, Türkiye
[2]Department of Physical Therapy and Rehabilitation, İstanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty, İstanbul, Türkiye
[3]Department of Biostatistics, İstanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty, İstanbul, Türkiye

ABSTRACT

Objectives: This study aimed to evaluate the accuracy of four clinical tests confirmed by ultrasonography (USG) and to evaluate the role of age, sex, handedness, subcutaneous tissue thickness (STT), tendon thickness (TT), and STT/TT in determining the absence of the palmaris longus muscle.

Patients and methods: In this descriptive study, 282 wrists of 141 healthy individuals (71 females, 70 males; mean age: 29±9.6 years; range, 21 to 55 years) were included between September 2021 and November 2022. The palmaris longus muscle tendon was identified by Schaeffer's test, Mishra's test I, Thompson's test, and Pushpakumar's test and then evaluated with USG. Before the tests, age, sex, and dominant hand information of the individuals were obtained. The STT and TT were measured with USG.

Results: Sensitivity values by side were as follows (right/left respectively): Schaeffer's 92%/73%, Mishra's I 91%/93%, Thompson's 84%/87%, and Pushpakumar's 86%/91%. Specificity values by side were as follows (right/left respectively): Schaeffer's 87%/95%, Mishra's I 78%/82%, Thompson's 78%/79%, and Pushpakumar's 84%/82%. Sensitivity values by sex were as follows (female/male respectively): Schaeffer's 81%/96%, Mishra's I 92%/94%, Thompson's 85%/90%, and Pushpakumar's 91%/92%. Specificity values by sex were as follows (female/male respectively): Schaeffer's 68%/90%, Mishra's I 72%/90%, Thompson's 72%/85%, and Pushpakumar's 78%/85%. The intraclass correlation coefficient between clinical tests and USG was 0.94 for the left side and 0.95 for the right side.

Conclusion: Mishra's test I and Pushpakumar's test can be used in females, while Schaeffer's test and Mishra's test I can be used in males as a mutually supportive clinical test. Furthermore, while there may be false negative and false positive test results due to muscle variations, it should be noted that STT/TT is also effective, particularly on the right side.

Keywords: Mishra I, Palmaris longus muscle, Pushpakumar, Schaeffer, Thompson, ultrasonography.

The palmaris longus muscle (PLM) belongs to the superficial flexor muscles of the forearm. It is a fusiform muscle and originates from the medial epicondyle and epicondylar ridge of the humerus and distal tendon, inserting into the ligamentous palmar aponeurosis.[1] The PLM is located between the flexor carpi radialis laterally and flexor carpi ulnaris tendons medially.[2] The PLM flexes the wrist weakly. Its main function is to stretch the skin and palmar fascia of the hand and reduce excess force on the palmar aponeurosis in the distal direction.[3-6] Abduction of the thumb is another function of the PLM.[6] In addition, it has been observed that the PLM works synergistically with the thenar muscles.[7] The PLM is frequently preferred in surgery due to its easy accessibility, and there is no loss of biomechanical function in the hand in the absence of it. It is used as a tendon graft for lip augmentation, tendon injuries, ptosis correction, and facial paralysis treatment.[2,3,8-11] Furthermore, due to the topographical proximity of the PLM and the median nerve, it should be known for certain in case the muscle is variably absent, and

Corresponding author: Zennure Adıgüzel Şahin, MD. İstanbul Üniversitesi, Cerrahpaşa Tıp Fakültesi, Anatomi Anabilim Dalı, 34098 Fatih, İstanbul, Türkiye.
E-mail: zennure.sahin@iuc.edu.tr

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the median nerve should not be damaged during surgery or interventional procedures.[12] Therefore, confirmation of the presence of a PLM tendon is critical for surgical planning. Considering the studies, the possibility of the absence of the PLM varies according to ethnic groups. This possibility ranges from 0.6% in the Korean population to 63.9% in the Turkish population.[4,6,8,13-19] Eleven clinical tests have been described in the literature that help identify the presence of the PLM.[20] However, not all of these tests can give the same result regarding the presence of PLM. Ultrasonography (USG), which is noninvasive and cheaper than many imaging methods, gives accurate information about the presence of the PLM. However, USG evaluation may not always be possible. A preliminary plan could be made with reliable clinical tests and a final decision could be made at an appropriate time with USG. That is why the usage rate of clinical tests is quite high. Thus, there are few studies investigating the correlation between USG and clinical tests.[2,11,21] The primary aim of this study was to establish the specificity, sensitivity, and accuracy of the first four clinical tests most commonly used in the evaluation of the PLM compared to USG in the detection of the PLM tendon.[22] Furthermore, this study aimed to establish the effects of sex, age, dominant hand, and subcutaneous tissue thickness (STT)/tendon thickness (TT) parameters on false negative/positive results of the clinical tests used.

PATIENTS AND METHODS

In this descriptive study, 282 wrists of 141 healthy individuals (71 females, 70 males; mean age: 29±9.6 years; range, 21 to 55 years) were included between September 2021 and November 2022. The study was conducted with volunteer patients who applied to the outpatient clinic and underwent forearm USG for any reason, as well as medical faculty students who wanted to participate in the study. Among these individuals, individuals who had trauma to the forearm/wrist or surgery and those who could not cooperate during USG or testing were not included in the study. The information regarding age, sex, and handedness was collected. Afterward, the presence or absence of the PLM tendon was identified by the Schaeffer's test, Mishra's test I, Thompson's test, and Pushpakumar's test and recorded. A written informed consent was obtained from each patient. The study protocol was approved by the Istanbul University Cerrahpasa Faculty of Medicine Ethics Committee (date: 17.04.2018, no: 143611). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Three different researchers first applied these clinical tests to 10 people twice at different times, and intrarater reliability was evaluated. The before and after test results of each researcher were compared, and the researchers continued to work in this study ($p<0.05$). Afterward, three researchers applied these tests to 20 people at different times without knowing each other's test results, and the interrater reliability was evaluated. As this evaluation also resulted in $p<0.05$, these researchers continued the study. The gold standard was the USG result for this evaluation. Four clinical tests were applied on both wrists of 141 individuals, and the presence or absence of the PLM tendon was recorded.

In Schaeffer's test, the thumb is opposed to the little finger, and then the wrist is flexed.[22] In Thompson's test, the patient is first instructed to make a fist and then flex the wrist.[23] In Mishra's test I, the examiner hyperextends the metacarpophalangeal joints of all fingers, and then the subject flexes the wrist.[24] In Pushpakumar's test, the subject extends the index and middle finger and the other fingers and flexes the wrist. Finally, the subjects oppose and flex their thumb.[25]

The STT and TT measurements taken were measured to investigate the cause of false negatives. The absence of the PLM tendon was detected with at least three of the tests applied; however, if the USG demonstrated the presence of the tendon, this result was considered false negative for the clinical tests.

All ultrasonographic evaluations were performed by two physiatrists with more than 15 years of experience in musculoskeletal USG examinations who were blinded to the clinical tests. Intra- and interrater evaluations were made from the USG results. The results of the physiatrist who was more experienced in locomotor system USG were determined as the gold standard. When the results were reliable ($p<0.05$), the USG was continued to be made by two different physiatrists.

An ESAOTE My Lab 70 USG system (Esaote SpA, Genoa, Italy) with a 4 to 13 MHz linear probe was used. All patients were scanned in sitting position with their forearms in supination and elbows in 90° flexion. The probe was placed axially, directly onto the palmar surface of the wrist to determine the presence or absence of the PLM tendon. At this level, the PLM tendon was searched superficially over the flexor retinaculum. The structure, which

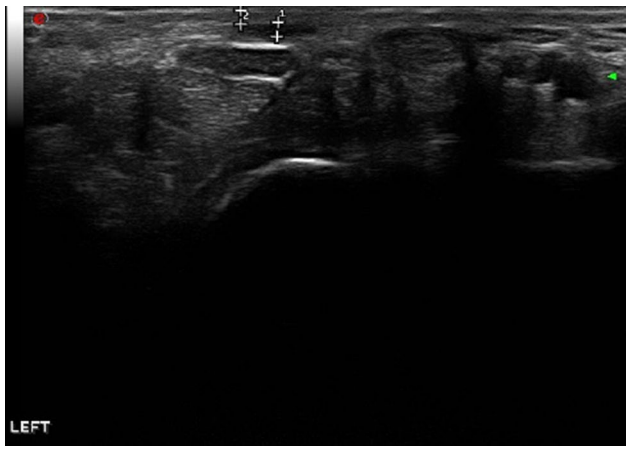

Figure 1. An ultrasonography image demonstrating (1) tendon thickness and (2) subcutaneous tissue thickness.

was presumed to be the PLM tendon, was scanned proximally and followed in the axial plane up to the muscle belly. When the PLM tendon was present, the TT and the STT in the transverse plane at the level of the ulnar styloid process were determined using the measurement tool on the USG system (Figure 1). If the PLM tendon could not be determined at the wrist level, an attempt was made to detect the muscle belly in the proximal forearm region. In patients whose proximal muscle bellies were observed on USG, the structure was scanned to the distal and followed to the tendon insertion.

If the PLM tendon was not visible or if any anatomical variation was suspected, both physicians repeated the ultrasonographic examination together to identify possible pitfalls in the examination (e.g., abnormal PLM insertion, relatively small tendon, STT, reverse PLM, and accessory muscles).

Statistical analysis

Data were analyzed using IBM SPSS version 22.0 software (IBM Corp, Armonk, NY, USA). Data were presented as mean ± standard deviation (SD), frequency, and percentage. The chi-square test and Fisher exact test were used to compare frequencies and percentages between groups. The nonparametric Cochran's Q test and the Wilcoxon signed-rank test were used in appropriate experimental setups. Backward stepwise logistic regression (Wald test) was performed to detect determinations between lifetimes and reveal trends that maintained the detected correlations. Furthermore, an intraclass correlation coefficient assessment was done. A p-value <0.05 was considered statistically significant.

TABLE 1
Sensitivity and specificity of clinical tests

	Schaeffer left		Schaeffer right		Mishra I left		Mishra I right		Thompson left		Thompson right		Pushpakumar left		Pushpakumar right		USG left	USG right
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	n
Tendon presence	96		93		102		97		98		95		101		95		103	104
Tendon absence	45		48		39		44		43		46		40		46		38	37
Specificity		95		87		82		78		79		78		82		84	100	100
Sensitivity		73		92		93		91		87		84		91		86	100	100

USG: Ultrasonography.

TABLE 2
Clinical tests sensitivity and specificity values by sex

	Schaeffer	Mishra I	Thompson	Pushpakumar
Specificity				
Male	90	90	85	85
Female	68	72	72	78
Sensitivity				
Male	96	94	90	92
Female	81	92	85	91

RESULTS

The mean age of females was 29.6±9.4 years, and the mean age of males was 28.4±9.8 years. There was no significant difference in age between female and male subjects (p>0.05). The dominant hand of 136 (96.45%) individuals was right, and five (3.55%) of them preferred the left. There was no significant difference in the dominant hand between female and male subjects (p>0.05). Intraclass correlation coefficient between clinical tests and USG was 0.94 for left and 0.95 for right.

In this study, the sensitivity and specificity of the tests were established by comparing the results of four clinical tests applied to 282 wrists and the results of the presence and absence of PLM tendon by examining 282 wrists with USG (Table 1). Table 2 shows the test sensitivity and specificity values by sex.

There was a significant difference between USG and clinical tests only in males and on the right side (p=0.042; calculated by Cochran's Q test). Seven false negative decisions were made on the left side (4 females and 3 males), and 13 on the right side (6 females and 7 males). Sex did not have a significant effect on physical examination and USG compatibility (right side, p=0.487; left side, p=0.736). Since the ages of the individuals were similar, a meaningful evaluation of the effect of age could not be made. Handedness did not have a significant effect on the clinical test and USG compatibility (right side, p=0.440; left side, p=0.150). The effect of the STT/TT ratio on clinical tests and USG compatibility was calculated by logistic regression, with p=0.006 for the right side and p=0.906 for the left side. The STT, TT, and STT/TT of the right and left sides of female and male individuals were compared using the Wilcoxon signed-rank test, with respective p-values of 0.586, 0.850, and 0.429. The STT, TT, and STT/TT were compared according to handedness using the Wilcoxon signed-rank test, with respective p-values of 0.181, 0.210, and 0.632. In addition, it was determined that eight individuals (5 females and 3 males) were given false positive results with the tests.

DISCUSSION

The PLM is a frequently preferred muscle in tendon grafts due to its anatomical accessibility and the fact that it is not felt in the absence of the muscle.[2,8,20] The PLM also has anatomical importance because it lies just superficial to the median nerve. Due to this close proximity, the median nerve is at great risk during surgery in a variant PLM. In cases where the PLM tendon is not congenital, the median nerve and tendon may be misidentified. Unfortunately, there are examples of faulty surgeries related to this situation.[12,20] It is vital that such a devastating risk is minimized. Therefore, before the planned surgical operations related to the PLM, possible anatomical information about the muscle should be obtained. At this stage, the most reliable and cheapest method is USG. However, in terms of practicality and since access to USG is not easy in every institution, clinical tests are also widely used to examine the PLM tendon. In this study, we wanted to determine the reliability of the four most frequently used clinical tests[11] to make the most accurate decision in cases where the decision about the presence and absence of muscle must be made by testing.

According to the study data of Johnson et al.,[21] sensitivity of Schaeffer's test, Thompson's test, Mishra's test I, and Mishra's test II is 94%, 72%, 100%, and 100%, respectively. Specificity of these respective tests is 94%, 91%, 83%, and 89%.[21] The data in our study is presented in Table 1. When the sensitivity and specificity results of Johnson et al.[21] are compared to our study, the sensitivity of Schaeffer's test on the left side in our study is quite low, while the results are similar on the right side

(left side, 73%; right side, 92%). In the specificity of Schaeffer's test, the right side is lower in our study (left side, 95%; right side, 87%). In Mishra's test I, the sensitivity in our study was high but not 100% (left side, 93%; right side, 91%). Closer values are observed in specificity (left side, 82%; right side, 78%). While our results for Thompson sensitivity are higher (left side, 87%; right side, 84%), our results for specificity are lower (left side, 79%; right side, 78%). Pushpakumar's test could not be compared since it was not included in the study of Johnson et al.[21] The test with the highest sensitivity and specificity for the right side in our study was Schaeffer's test. For the left side, the test with the highest sensitivity was Mishra's test I, while the test with the highest specificity was Schaeffer's test. If information about the presence of PLM tendon is to be obtained according to the clinical test, it may be appropriate to apply these two clinical tests to the same person.

In addition, the most sensitive test in females was Mishra's test I (Table 2). This finding is similar to the study of Kose et al.[17] In males, Schaeffer's test, which is the most sensitive test for the general participant, appears to be more sensitive than the others. In terms of specificity, Pushpakumar's test for females and Schaeffer's test and Mishra's test I for males are in the first place. Therefore, Mishra's test I and Pushpakumar's test can be used for females, whereas Schaeffer's test and Mishra's test I male can be used for males as a mutually supportive clinical test. Ndou et al.[18] also observed that there may be more sensitive tests than Schaeffer's test.

There is a significant difference between clinical test results and USG results on the right side in males (p=0.042). This information can be taken into account when examining the PLM tendon with a right-sided clinical test in males. In such a case, more confident steps can be taken if the clinical test is performed without much confidence.

With the support of the literature,[26] the possibility that one of the factors that may cause false negatives in the clinical test, the PLM tendon of the other side may be thinner than the dominant hand, was evaluated. However, since the number of left-handed individuals participating in the study was not enough, the result was not directive. Therefore, the study can be repeated with more left-handed people.

The result that the STT/TT ratio can cause false negatives on the right side is important. Since there is no significant difference between the STT, TT, and the STT/TT ratio in males and females, an appropriate imaging method may be requested, particularly on the right side, if possible, as a result of a negative clinical test in both males and females.

Before deciding that there is no PLM tendon according to the clinical test, it should be kept in mind that there may be muscle variation. Different variations can be observed in the PLM, such as the reverse muscle and the tendon course being more medial or lateral.[27,28]

In false positive results, the flexor carpi radialis (FCR) muscle tendon has a thicker and more dominant tendon than the PLM tendon or the FCR course is more medial than expected.[11,29] In addition, although rare, some FCR variations can make a positive decision due to the tendon appearance despite the absence of PLM.[30] In this study, there was no variation in individuals with a false positive decision, possibly the examiner confused the PLM tendon with the FCR tendon.

There are very few studies in the literature on the sensitivity and specificity of clinical tests. In this respect, we believe that this study is important. We hope that the data of this study will contribute to the literature and be used in the clinic. For these obtained data to be more reliable, the study needs to be expanded. These tests can be applied again by forming groups in the form of occupations that require intensive hand use and those that do not. We believe that new data can be obtained by increasing the number and including different age groups in the study. In addition, about 11 clinical tests applied to understand the presence of the PLM tendon have been identified in the literature. Other than the four tests in this study, they can be evaluated by applying them in a similar study.

There are some limitations to this study. The absence or presence of the PLM tendon and thickness measurements were evaluated only by USG. Measurements could have been confirmed by other imaging methods. The study also needs to be conducted with a larger population and in different age groups.

In conclusion, Mishra's test I and Pushpakumar's test can be used in females, while Schaeffer's test and Mishra's test I can be used in males as a mutually supportive clinical test. Furthermore, while there may be false negative and false positive test results due to muscle variations, it should be noted that STT/TT is also effective, particularly on the right side.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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