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FPL tendon thickness, tremor and hand functions in Parkinson‘s disease

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Abstract: Introduction: In Parkinson’s disease (PD), a resting tremor of the thumb may affect the flexor pollicis longus (FPL) and influence hand functions. We investigated the relationship between FPL tendon thickness and hand function in PD patients and compared these characteristics with those in healthy controls.

Methods: The hand grip and pinch strengths were measured. The participants completed the Duruöz hand index, the Sollerman’s hand function test, and the Nine Hole Peg Test. The thickness of the FPL tendon was measured using ultrasonography.

Results: The FPL tendon was thicker in PD patients but was not associated with tremor severity. In PD patients, despite functional performance of the hands are impaired and grip strength is decreased, pinch strengths are preserved. FPL thickness was not correlated with grip and pinch strengths.

Conclusion: The thicker FPL tendon may be associated with greater pinch and grip strengths and manual dexterity in healthy individuals. The presence of tremor is associated with a thicker FPL tendon.

Keywords: Parkinson’s disease, tremor, tendon imaging, hand function

1 Introduction

Parkinson’s disease (PD) is a chronic and progressive neurodegenerative movement disorder affecting approximately 1% of individuals older than 60 years [1]. The main clinical features of PD are tremor, rigidity, bradykinesia, and postural instability [2]. About 60% to 70% of the patients present with tremor in an upper extremity, and tremor may remain as the main manifestation of PD for several years [3]. The most common tremor is rest tremor; various types of rest tremor and rest tremor in combination with postural tremor may occur in patients with PD [4]. An upper extremity tremor generally begins in the fingers or thumb, but it can also start in the forearm or wrist. The tremor may spread to the ipsilateral lower extremity or the contralateral upper extremity; however, asymmetry is usually maintained [1, 5].

A ‘Pill Rolling’ rest tremor is a characteristic rest tremor affecting the thumb and index finger in PD. Patients with PD may have impairments in hand function and activities of daily living (ADL) resulting from rest tremor, rigidity, and bradykinesia [6]. The flexor pollicis longus (FPL) is the flexor of the distal phalanx of the thumb that can assist wrist flexion. The functional impairment of this muscle may lead difficulties in gripping or grasping objects.

We hypothesized that the FPL muscle as the flexor of the thumb may be affected by the rest tremor, and that this may influence hand functions in patients with PD. The objective of this descriptive, controlled, and cross-sectional study study was to investigate the relationship between sonographic FPL tendon thickness and hand function, both in healthy controls and patients with PD.

2 Material and methods

In total, 46 patients (35 male, 11 female) were recruited from the neurology outpatient clinic of Afyon Kocatepe University. The age- and sex-matched 40 healthy controls (30 male, 10 female) were enrolled from the healthy

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subjects accompanying the patients during their visits to the hospital or from the hospital staff. All subjects were informed about the procedure, and they consented to participate. The study was approved by the local Committee for Medical Research and Ethics at the Afyon Kocatepe University Faculty of Medicine (approval number 2012/4-26; approval date August 02, 2012).

The age, gender, and side of the dominant hand of patients and controls were recorded. The severity of tremor of PD patients was classified into five degrees (0=absent; 1=slight and infrequently present; 2=moderate, bothersome to patient; 3=severe, interferes with many activities; 4=marked; interferes with most activities) and evaluated by an experienced neurologist (6). The hand grip strength (HGS), key pinch strength (KPS), and tip pinch strength (TPS) of the right and left hands of all participants were measured. The participants were asked to fill out a Duruöz hand index (DHI) questionnaire and perform Sollerman's hand function test (SHFT) and the Nine Hole Peg Test (NHPT) (with each hand).

HGS was measured according to the recommendations of the American Society of Hand Therapists, as described by Mathiowetz et al. [7], using a baseline hydraulic hand dynamometer (Fabrication Enterprises Inc., White Plains, New York, USA) set at the second smallest hand position. Three measurements were performed, and the average of these measurements was recorded for final analysis. The pinch strength measurements KPS and TPS were recorded while the participants were seated upright against the back of a chair without armrests, feet flat on the floor, shoulders adducted and neutrally rotated, elbow flexed to 90°, and the forearm and wrist in neutral positions. KPS was defined as the thumb pad to radial aspect of the middle phalanx of index finger and TPS as the thumb tip to index fingertip [7]. All pinch measures were obtained using a baseline mechanical pinch gauge (Fabrication Enterprises Inc., White Plains, New York, USA). Three measurements were performed, and the average of these measurements was recorded for final analysis. Participants were asked to exert maximal effort for 3 seconds and were given a 10-second rest period between HGS, KPS, and TPS measurements.

2.1 Nine Hole Peg Test

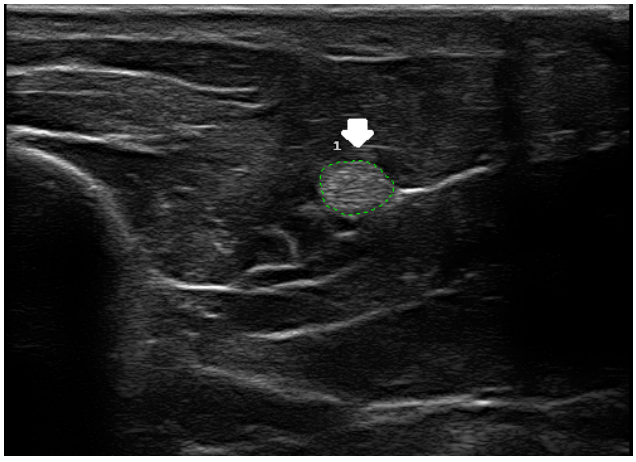
The NHPT is a commercially available, standardized, well established, and reliable measure of hand function for healthy adults, and it was validated for assessing upper extremity function in individuals with PD [8]. The test requires participants to quickly pick up 9 small pegs from a holding well, place them into holes on a board, and then move them back to the well. The test was performed three times with each hand, and the average of three measurements was analyzed.

2.2 Sollerman Hand Function Test

The Sollerman hand function test comprises 20 activities of daily living tasks, each having a number of prescribed grip patterns. It is based not only on the time needed to finish tasks, but also on the quality of movement (the grip patterns that are used in the task). The score range for each task was 0 to 4, which amounted to the maximum of 80 points for all 20 tasks. Normal hand function would achieve 80 points with the dominant hand and 77 to 79 points with the nondominant hand [9, 10].

The Duruoöz Hand Index (DHI) is a functional disability scale 15 that can be used successfully to assess functional disability with different hand arthropathies. It has been validated for hand involvement in rheumatoid arthritis (RA), osteoarthritis, systemic sclerosis, and stroke patients [11].

The thickness cross-sectional area (CSA) of the FPL tendon was measured using ultrasonography. During ultrasonographic imaging, a 6 to 18 MHz multifrequency linear probe (Esaote MyLab Xvision, Italy) was used. All measurements were performed by the same investigator. The circumference and CSA of the FPL tendon were measured from the middle point of the line between first metacarpophalangeal joint and carpometacarpal joint using a continuous boundary trace of the tendon. Area calculations were automatically performed by the ultrasound device software. The angle of the ultrasound beam was



1: Ultrasonography (B-mode) shows the axial view (white arrow) of the FPL tendon at midpoint between the fist carpometacarpal and metacarpophalangeal joint.

kept perpendicular to the surfaces of the tendon to have the highest echogenic view, and no additional pressure was applied.

2.3 Statistical analysis

Data were analyzed using SPSS 15.0 for Windows. Descriptive statistics are given as mean ± SD. The chi-square test was used to compare categorical variables. The Kolmogorov-Smirnov test was used to determine whether data followed a normal distribution. The Student's *t*-test was used to compare continuous variables with a normal distribution. The correlations were evaluated with Pearson or Spearman correlation tests as appropriate. The level of significance was set at $p< 0.05$.

2.4 Results

In total, 46 patients with PD and age- and sex-matched 40 healthy controls were included in the study. The patient characteristics and HGS, lateral pinch, fingertip pinch strengths, SHFT and DHI scores, right and left NHPT score and FPL tendon CSA's of patients, controls. The significance level of the differences between these two groups are shown in Table 1.

In healthy controls, the mean thickness of the right FPL tendon was greater than that of the left. Hand grip, key pinch, and tip pinch strengths were significantly greater on the right side. Likewise, NHPT scores were better on the right side (Table 2). In PD patients, FPL tendon CSA, HGS, KPS, and TPS were higher on the right side, but the differences were significant only in KPS and TPS. The NHPT score was similar on the right and left side (Table 2).

Between-group analysis revealed that right FPL mean thicknesses were similar in PD patients and healthy controls, whereas the left FPL was thicker in PD patients. HGS of the both hands were higher in healthy controls, but the diffference did not reach statistical significance on the left hand. Key pinch and tip pinch strengths of the right and left hands did not differ between the two groups. NHPT on both sides, SHFT, and DHI scores were significantly worse in PD patients (Tables 1 and 2).

The association of the FPL thickness with HGS, KPS, TPS and the hand function test scores were analyzed. There was no association between right FPL thickness and the HGS, KPS, TPS, NFPT, SHFT, and DHI scores in PD patients ($p>0.05$ for all). Right FPL thickness was associated with DHI score only in healthy controls (r:0.327, p:0.020). Although the left FPL tendon thickness showed an association with DHI score (r:352, p:0.016), there was no significant association with the other parameters in PD patients ($p>0.05$). In healthy controls, the left FPL tendon thickness was significantly associated with DHI, HGS, and TPS (r: 0.414, p:0.003, r:0.296, p:0.037 and r: 0.318, p:0.024, respectively).

The FPL thicknesses in both right and left hands did not change according to the severity of the tremor (p:0.460 and p:0.910, respectively).

3 Discussion

This preliminary study revealed that, in association with higher grip and pinch strengths and better functional performance, the FPL tendon was thicker on the right hand compared with the left in healthy subjects with dominant a right hand. In PD patients, FPL tendon thicknesses and functional performance were similar on the right and left hands. However, pinch strengths were significantly greater on the right hand. In patients with PD, despite functional performance of the hands being impaired and the grip strength decreased, pinch strengths are preserved. Furthermore, FPL thickness was not correlated with grip and pinch strengths. The left FPL tendon was thicker in PD patients, but the thickness of left FPL was

Table 1: Demographic data and hand function test scores assigned to PD patients and healthy controls, and the significance of the difference between groups.

	PD Patients	Controls	p
Age	65.5 ± 9.3	63.4 ± 9.9	*0.689*
Gender (male/female and percentages)	35 (76%) / 11 (24%)	30 (75%) / 10 (25%)	0.907
Dominant hand (right/left and percentages)	44 (96%) / 2 (4%)	39 (98%) / 1 (2%)	*0.511*
Sollerman Hand Function test	70.65 ± 3.1	78.1 ± 1.4	*<0.001*
Duruöz Hand Index score	69.7 ± 7.9	87.9 ± 2.1	*<0.001*

PD: Parkinson's disease. Data are expressed as mean ± SD.

Table 2: FPL tendon thicknessess, HGS, KPS, TPS, and NHPT values of the right and left hands in the two groups. The *p* value on the right column represents the significance of the differences between groups, whereas the *p* values on the line under each variable represent the significance of the differences between right and left hands in the two groups seperately.

	PD patients	Controls	*p*
FPL CSA Right	9.5 ± 2.4	8.96 ± 2.3	*0.263*
FPL CSA Left	9.2 ± 2.2	7.7 ± 2.0	***0.001***
p	*0.220*	***<0.001***	
HGS Right	27.3 ± 8.2	32.5 ± 11.7	***0.014***
HGS left	26.7 ± 8.3	30.8 ± 12.3	*0.059*
p	*0.287*	***0.001***	
Key pinch right	8.0 ± 2.4	8.5 ± 2.9	*0.326*
Key pinch left	7.5 ± 2.3	8.2 ± 3.0	*0.238*
p	***0.005***	***0.007***	
Tip pinch right	6.2 ± 2.0	6.7 ± 2.3	*0.222*
Tip pinch left	5.9 ± 2.0	6.4 ± 2.3	*0.269*
p	***0.012***	***0.003***	
NHPT Right	38.8 ± 14.3	24.9 ± 3.9	***<0.001***
NHPT left	37.5 ± 10.4	25.6 ± 4.1	***<0.001***
p	0.474	**<0.001**	

FPL CSA: Flexor pollicis longus tendon cross sectional area, HGS: Hand grip strength, NHPT: Nine Hole Peg Test.

associated with DHI score only in PD patients. Although the severity of tremor does not affect FPL tendon thickness, the FPL tendon is thicker in PD patients.

In the study by Goetz et al. that evaluated the contribution of the flexor pollicis longus (FPL) to key pinch strength, FPL paralysis resulted in a statistically significant decrease in KPS (56%) and TPS (43%), whereas the HGS did not change significantly. The authors reported that the FPL muscle contributes approximately half of the measured force in pinch [12]. In PD, the impairment in upper extremities led to progressive limitations in activities such as reaching, grasping, and various fine motor tasks [13]. The patients with PD have difficulties in motor learning and skill acquisition, and in particular with performance of sequential tasks that require rapid alternation of movements [14]. Bradykinesia, hypokinesia, rigidity, and tremors disable patients with PD and lead to impairment in manual dexterity. These impairments manifest in timing difficulties and force modulation and affect the quality of hand function in a progressive manner [13]. However, patients with PD may exhibit excessive gripping forces and delayed movement initiation when they grasp and lift a small object with a precision grip [15, 16]. In addition, patients with PD may have difficulties with individual finger movement even though gross hand movement is normal [17]. The deficits in movement speed, force timing, and modulation may negatively affect functional abilities in PD patients [13]. Likewise, the current study demonstrated decreased grip strength and worse functional performance despite similar pinch strengths in patients with PD. Accordingly, the impaired hand function in PD might result from bradykinesia, rigidity, and impaired control rather than from FPL strength.

This study has some limitations. First, we did not evaluate rigidity and bradykinesia in PD patients as they may affect NHPT, SHFT, and DHI scores. The measurement of the rest tremor was subjective; however, it was performed by the same experienced neurologist. The tremor in PD usually has an asymmetric presentation; unfortunately, we did not not record side of the hand on which the tremor initially occurred, but all patients included in the study had tremor bilaterally.

In conclusion, the thicker FPL tendon may be associated with greater pinch and grip strengths and manual dexterity in healthy individuals. The presence of tremor is associated with a thicker FPL tendon. Despite decreased performance of the hands in patients with PD, key pinch and tip pinch strengths are preserved. These preliminary results should be supported in further studies that evaluate relationships between FPL tendon thickness and hand function.

Conflict of interest statement: Authors state no conflict of interest

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