Ultrasonographic assessment of quadriceps and patellar tendon thicknesses in patients with patellofemoral pain syndrome

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A R T I C L E   I N F O

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A B S T R A C T

Objective: The aim of this study was to compare ultrasonographically measured quadriceps and patellar tendon thicknesses between Patellofemoral Pain Syndrome (PFPS) patients and age- and gender-matched healthy controls.

Methods: Among patients who presented to physical therapy and rehabilitation outpatient clinic in January–December 2016, 61 volunteers (28 men and 33 women; mean age: 30.79 ± 6.55 years) who were eligible considering the inclusion and exclusion criteria were enrolled. 30 were diagnosed with PFPS, and the remaining were age- and gender-matched healthy volunteers. Mean age was 30.03 ± 5.67 years in healthy subjects and 45.2% were of male gender. The patient group had mean age of 31.57 ± 7.37 years and 46.7% of the patients were male. Q angles were measured at standing, supine and sitting positions. Patellar and femoral tendon thicknesses and areas were measured ultrasonographically. Kujala questionnaire were used to evaluate the functional status of the participants.

Results: No significant difference was detected between groups regarding profession, educational background, and body mass indices (BMI) (p > 0.05). Q angle values were significantly higher in the patient group when compared to controls at standing (17.03 ± 3.84 vs. 13.87 ± 1.75°, p < 0.001), supine (16.20 ± 3.74 vs. 13.45 ± 1.79°, p = 0.001) and sitting (16.50 ± 3.28 vs. 13.71 ± 1.72°, p < 0.001) positions. Kujala score was significantly lower in the PFPS group when compared to controls (70.57 ± 8.37 vs. 98.58 ± 2.05, p < 0.001). Patellar (0.39 ± 0.08 vs. 0.32 ± 0.05 cm, p < 0.001) and quadriceps (0.64 ± 0.10 vs. 0.52 ± 0.09 cm, p < 0.001) tendon thicknesses were significantly higher in the PFPS group when compared to controls. There was no significant difference between groups regarding patellar tendon areas (p > 0.05). Patellar tendon thickness values of ≥0.35 cm were found to have 66.7% sensitivity and 67.7% specificity for PFPS diagnosis in the ROC curve analysis (area under curve: 0.771, 95% confidence interval: 0.655–0.887, p < 0.001). Quadriceps tendon thickness values of >0.54 cm were found to have 80% sensitivity and 71% specificity for PFPS diagnosis in the ROC curve analysis (area under curve: 0.784, 95% confidence interval: 0.710–0.939, p < 0.001). In PFPS patients, quadriceps tendon thickness had significant positive correlation with age (r = 0.405, p = 0.027) and BMI (r = 0.450, p = 0.013); and significant negative correlation with Kujala score (r = −0.441, p = 0.015). In the multivariate regression analysis, quadriceps tendon thickness was independently associated with the presence of PFPS (Exp(B) = 3.089, 95% confidence interval: 1.344–7.100, p = 0.008).

Conclusion: Our study demonstrates that ultrasonographically measured patellar and quadriceps tendon thicknesses are significantly higher in subjects with PFPS and particularly, quadriceps tendon thickness may be used for the diagnosis.

Level of Evidence: Level III, Therapeutic Study.

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Introduction

Patellofemoral pain syndrome (PFPS) is a common clinical condition that is characterized by anterior knee pain.1 Severe pain
occurs in proximity of patella during flexion of the knee due to weight-bearing nature of the knee joint. Pain is positively correlated with the amount of stress on the joint. PFPS is commonly encountered in runners and subjects younger than 40 years old. In PFPS, anatomic or functional abnormalities may be seen in patella, musculotendinous junctions, or both. Although not fully elucidated, PFPS is thought to be a multifactorial disease. Abnormal lower extremity alignment (increased Q angle, genu valgum, tibia varum, structural abnormalities of the patella, etc.), weakness of the muscles located around the knee and hip joints and excessive physical activity are among the leading causes. These are believed to result in impaired knee extension, increased patellofemoral contact pressure and patellofemoral joint stress, eventually leading to PFPS development.

Diagnosis of PFPS is made by clinical evaluation. History and physical examination have important role in diagnosis. Kujala score and visual analog scale (VAS) may be used for the assessment of functional status and pain severity, respectively. In contrary, imaging modalities are of limited use in PFPS diagnosis. A specific imaging finding does not exist for PFPS and imaging modalities are frequently used for exclusion of alternative diagnoses.

The possible changes in quadriceps and patellar tendon thicknesses in PFPS patients have not been evaluated yet. In this study, we aimed to compare quadriceps and patellar tendon thicknesses between control subjects and PFPS patients and determine whether tendon thicknesses had a diagnostic value in PFPS. In addition, we sought to investigate the relationship between quadriceps and patellar tendon thicknesses with functional scoring and pain severity in the patient group.

Materials and methods

Study population

Among patients who presented to physical therapy and rehabilitation outpatient clinic in January–December 2016, 61 volunteers who were found eligible were included in the study. Thirty participants were diagnosed with PFPS, the remaining 31 were age and gender-matched control subjects. Local ethics committee approved the study (2016/706) and informed consent was obtained from all participants.

Patients aged between 18 and 45 years and have recurrent knee pain episodes when crouching or anterior knee pain episodes after sitting with the knee flexed that lasted more than a month and positive patellar grind test were included in the study. All of the patients included in the study had knee MRI for the exclusion of other pathologies those may be related to the anterior knee pain. Patients with clinical symptoms related to other knee pathologies, patellar subluxation/dislocation, prior knee surgery, hip-spine related pain episodes, knee effusion, meniscal or intra-articular pathologies or lesions of ligaments, inflammatory diseases such as rheumatoid arthritis or ankylosing spondylitis were excluded.

Clinical evaluation

Detailed history and physical examination findings were recorded. In order to exclude other pathologies that cause knee pain; patellar plica tests (to exclude plica syndrome), Apley compression and distraction tests, McMurray tests, varus-valgus stress tests, anterior and posterior drawer tests, pivot shift and Lachman tests (to exclude meniscus and cruciate ligament injuries) were performed. Quadriceps and patellar tendons, bursae and iliotibial band were palpated to assess tenderness. VAS pain scores were recorded both at rest and during activity. Kujala anterior knee pain scale was used to assess functional status of patients. Q angle was evaluated at supine, standing and sitting positions with the knees flexed 90° using a goniometer.

Ultrasonography

An experienced and blinded physician, using a linear 7–12 MHz probe (GE Logiq P5), performed ultrasonographic evaluations. Patellar tendon thickness was measured as previously described by Skou et al by placing the probe longitudinally and measuring the region 1 cm distal to the patellar apex. Patellar tendon area was measured axially from the region 1 cm distal to the patellar apex. Quadriceps tendon thickness was measured from the region 1 cm proximal to the patellar apex.

Statistical analysis

Shapiro–Wilk test was used to test whether parameters were normally distributed. Normally distributed parameters were presented as mean ± standard deviation and skewed continuous parameters were expressed as median (interquartile range defined as 25th percentile–75th percentile). Categorical data was expressed as number and percentages and were compared using Chi-square test. Independent samples t-test was used to compare two groups of normally-distributed parameters. Correlation between two parameters was assessed using either Pearson’s (in case of linear relationship) or Spearman’s test (in case of non-linear relationship). Binomial regression analysis was performed to determine the independent associates of PFPS presence. ROC curve analysis was used to determine the sensitivity and specificity of tendon thicknesses for the diagnosis of PFPS. A two-tailed p < 0.05 was considered statistically significant.

Results

Baseline sociodemographic and clinical characteristics of the study population

Baseline sociodemographic and clinical characteristics of the study population are shown in Table 1. Mean age of the study population was 30.79 ± 6.55 years and 45.9% of them were of male gender. Age (p = 0.367), gender (p = 0.906), educational and occupational status (p = 0.384, p = 0.190 respectively) were similar in healthy control and patient groups. BMI was also similar in healthy control and patient groups (p = 0.683).

Q angle was significantly greater in the patient group compared to healthy controls (standing: p < 0.001, supine: p = 0.001, sitting: p < 0.001). Kujala score was significantly lower in the patient group compared to healthy controls (p < 0.001). Patellar tendon area was similar in both groups (p = 0.624).

History and clinical assessment in the patient group

Details regarding history and clinical assessment in the patient group are shown in Table 2. Most of the PFPS patients (90%) had right-side dominance and the affected side was the right lower extremity in 73.3% of the patients. Median time from the onset of symptoms was 15 months and median duration of symptoms was 30 min. Median time to occurrence of knee pain with flexion was 5 min. Median VAS at rest and sitting were 0 and 6.5, respectively.
Correlation and ROC curve analysis in the patient group

The correlations between patellar tendon thickness and clinical parameters are shown in Table 3. Patellar tendon thickness was not significantly correlated with BMI, age, Q angle (standing/supine/sitting) or Kujala score in subjects diagnosed with PFPS. In addition, no significant correlation was found between patellar tendon thickness and time from the onset of symptoms, duration of symptoms, and time to occurrence of knee pain with flexion or VAS at sitting. There was a statistically significant positive correlation between patellar tendon thickness and VAS at rest (r = 0.396, p = 0.030). No statistically significant correlation existed between patellar tendon thickness and patellar tendon area or quadriceps tendon thickness. ROC curve analysis revealed that a patellar tendon thickness ≥0.35 cm determined the presence of PFPS with a sensitivity and specificity of 66.7% and 67.7%, respectively (AUC: 0.771, 95% confidence interval: 0.655–0.887, p < 0.001).

Independent associates of PFPS presence in the study population

Independent associates of PFPS presence were determined using binomial regression analysis and the results are given in Table 5. Following the univariate regression model, which included parameters that significantly differed between patient and control groups—namely patellar tendon thickness, quadriceps tendon thickness and Q angle (standing, sitting and supine)—a multivariate regression model was applied. Q angle measured in standing (OR: 2.120, p < 0.001), and quadriceps tendon thickness (OR: 3.089, 95% confidence interval: 1.173–7.100, p = 0.008) were found to be independent associates of PFPS presence.

Discussion

Patellofemoral pain syndrome is known to account for 25% of the knee injuries. Despite its high prevalence, no gold standard examination or imaging modality for PFPS diagnosis has been described. In our study, quadriceps and patellar tendon thicknesses...
measured using ultrasonography in PFPS patients have been compared with that of the age and gender-matched control subjects for the first time in the literature. Our findings suggest that patellar and quadriceps tendon thicknesses are significantly increased in PFPS patients and quadriceps tendon thickness may be used to determine PFPS presence.

Factors that have a role in PFPS pathogenesis may be classified under three main groups: factors related to the joint (local factors), factors related to the lower extremity biomechanics and factors related to exercise. Patellar hypermobility, weakness of quadriceps muscle and lack of flexibility of the soft tissue are among the local factors. Pelvic muscle dysfunction and gait abnormalities are among factors related to the lower extremity biomechanics. Quadriceps muscle is among the most important supporting structures of the patellofemoral joint. Observational studies have reported decreased quadriceps torque in subjects diagnosed with

Table 3
The relationship between patellar tendon thickness and clinical parameters in the patient group (n = 30).

| Clinical Parameter                        | Pearson Correlation Coefficient | P Value |
|------------------------------------------|---------------------------------|---------|
| Body mass index, kg/m²                   |                                 |         |
| Age, years                               |                                 |         |
| Q angle (standing)                       |                                 |         |
| Q angle (supine)                         |                                 |         |
| Q angle (sitting)                        |                                 |         |
| Patellar tendon area, cm²                |                                 |         |
| Quadriceps tendon thickness, cm          |                                 |         |

Table 4
The relationship between quadriceps tendon thickness and clinical parameters in the patient group (n = 30).

| Clinical Parameter                        | Pearson Correlation Coefficient | P Value |
|------------------------------------------|---------------------------------|---------|
| Body mass index, kg/m²                   |                                 |         |
| Age, years                               |                                 |         |
| Q angle (standing)                       |                                 |         |
| Q angle (supine)                         |                                 |         |
| Q angle (sitting)                        |                                 |         |
| Patellar tendon area, cm²                |                                 |         |
| Quadriceps tendon thickness, cm          |                                 |         |

VAS, visual analog scale for pain.
*p value < 0.05 denotes statistical significance.
A recent meta-analysis has demonstrated a significant relationship between quadriceps atrophy and presence of PFPS, when compared with the asymptomatic extremity and a healthy control group. An association between PFPS and atrophy in vastus medialis oblique (VMO) muscle, whose fibers attach to distal patella horizontally and contribute significantly to medial patellar stability, has also been reported. In contrary, whether a causal link exists between quadriceps and VMO atrophy and PFPS pathogenesis is still unclear. Currently, there are two prospective studies that aim to clarify this relationship. Although Milgrom et al had reported no association between knee extension strength and PFPS development, Boling et al described decreased quadriceps strength as a predisposing factor for PFPS. Pooled analysis of both studies has suggested a significant relationship between decreased knee extension strength and PFPS development. Loss of flexibility in soft tissues around the knee joint is accepted to be another risk factor for PFPS. Excessive strain related with the lateral of the knee, particularly originating from the lateral retinaculum, causes inappropriate positioning of the patella. Some cross-sectional studies have revealed an association between iliotibial band thickness and presence of PFPS. Iliotibial band has been reported to be stretched in most of runners diagnosed with PFPS. In our study, quadriceps tendon thickness, patellar tendon thickness, and patellar flexion angle (Q angle) were measured using ultrasonography in subjects diagnosed with PFPS. Both studies have suggested a significant relationship between quadriceps and VMO atrophy and PFPS pathogenesis. In this study, quadriceps tendon thickness determined using ultrasonography is found to be an independent predictor of PFPS in our study. This finding may facilitate the clinical diagnosis of PFPS.

**Limitations of the study**

Our study has failed to demonstrate any causality due to its cross-sectional design. In addition, lack of the evaluation for biomechanical stress parameters has limited the elucidation of the exact role of ultrasonographic assessment in PFPS pathogenesis.

**Conflicts of interest**

No conflict of interest.

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