

Is there any relationship between Q-angle and lower extremity malalignment?

Defne KAYA¹, Mahmut Nedim DORAL^{1,2}

¹Department of Sports Medicine, Faculty of Medicine, Hacettepe University, Ankara, Turkey;

²Department of Orthopedics and Traumatology, Faculty of Medicine, Hacettepe University, Ankara, Turkey

Objective: The aim of this study was to assess the relationship between Q-angle and lower extremity alignment in women with unilateral patellofemoral pain syndrome (PFPS).

Methods: Eighty-five women with unilateral patellofemoral pain participated in the study, with each subject acting as their own internal control using the unaffected limb. Lower extremity alignment and Q-angles of the affected and unaffected knees were compared.

Results: There was a significant difference in the Q-angle between the affected (19.61 ± 4.35) and the unaffected (17.63 ± 4.29) side ($p=0.00$). There was also a significant difference in the lateral distal femoral angle (LDFA) (81.00 ± 2.58 vs. 81.83 ± 3.03 ; $p=0.03$) and no significant difference in the medial proximal tibial angle (MPTA) (87.88 ± 2.63 vs. 87.60 ± 3.29 ; $p=0.51$) between the affected and the unaffected side. There was no relationship between the Q-angle and LDFA ($r=0.001$, $p=0.99$), and MPTA ($r=-0.051$, $p=0.64$) in the affected side of the patients. There was also no relationship between the Q-angle and LDFA ($r=0.179$, $p=0.64$), and MPTA ($r=-0.146$, $p=0.18$) in the unaffected side of the patients.

Conclusion: Increased Q-angle and decreased LDFA may be associated with PFPS although cause or effect cannot be established. There was no relationship between the Q-angle and lower extremity malalignment. Large prospective longitudinal studies are needed to detect changes in the femoral anteversion and toe-in gait and to establish if these features are a cause of PFPS.

Key words: Alignment; lower extremity; patellofemoral pain syndrome; Q-angle.

The Q-angle, described by Brattström, is an index of the vector of the combined pull of the knee extensor mechanisms and the patellar tendon.^[1] An increased Q-angle represents a larger lateral vector of the lower extremity caused by decreased knee abduction and decreased ground reaction forces.^[2,3] The Q-angle is widely used as practical measurement of patellofemoral dysfunction, patellofemoral pain syndrome (PFPS), and patella instability.^[4] Many authors have reported that a greater Q-angle ($>20^\circ$) is a risk factor for PFPS.^[5-8]

Several investigations have studied gait in PFPS. It is thought that an abnormal gait pattern can lead to PFPS due to excessive flattening of the medial arch and instability of the forefoot influencing internal rotation of the tibia, compensatory internal rotation of the femur,^[9-11] and consequently, patellar malalignment.^[12-14]

Lower extremity alignment is an important etiological factor in PFPS.^[5,9,11] The lateral distal femoral angle (LDFA) and medial proximal tibial angle (MPTA)

Correspondence: Defne Kaya, PT, MSc, PhD. Hacettepe Üniversitesi Tıp Fakültesi Spor Hekimliği Anabilim Dalı, Sıhhiye 06100, Ankara, Turkey.

Tel: +90 312 - 305 13 47 e-mail: defne@hacettepe.edu.tr

Submitted: September 4, 2011 **Accepted:** August 16, 2012

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Available online at
www.aott.org.tr
doi:10.3944/AOTT.2012.2883
QR (Quick Response) Code:



were used to assess lower extremity alignment^[8,15] and compared with the Q-angle in the present study.

Although there is some evidence of increased Q-angle in patients with PFPS, there have been no studies investigating the relationship between the Q-angle and lower extremity malalignment through radiological assessment. Our hypothesis was that women with PFPS would display an increased Q-angle and changed LDFA and MPTA at the affected side compared to the unaffected side. Therefore, the aim of this study was to analyze the relationship between the Q-angle and the lower extremity malalignment in women with unilateral PFPS.

Patients and methods

The study included 85 female patients with unilateral PFPS who did not receive any treatment for their PFPS. The patients' mean age was 43 ± 8 years, height 164 ± 8 cm, and weight 72 ± 12 kg. Evaluation parameters were approved by the local ethics committee and complied with the Declaration of Helsinki. Patients were informed about aims of the study and the testing procedure prior to their participation. Written informed consent was obtained from all patients.

Inclusion criteria were; the onset of pain longer than six months, no extremity length discrepancy, characteristic clinical signs (i.e., retropatellar pain, crepitation, and pain in patellar grinding) and positive clinical tests (Clarke's sign,^[16] active patellar grind test,^[17] direct patellar compression,^[17] palpation of the medial articular border of the patella,^[17,18] and palpation of the lateral articular border of the patella^[17,18]) of the syndrome at ages 30 to 55 years, no history or clinical evidence of patellofemoral dislocation, subluxation, or osteoarthritis or lower extremity surgery, absence of knee ligaments, bursae, menisci, and synovial plicae

dysfunction in clinical examination, and no cartilage, ligament and meniscal lesion in MRI assessment.

Leg length was measured with tape from the spina iliaca anterior superior (SIAS) to the medial malleolus and from the trochanter major to the medial malleolus. There was no significant difference in leg length between the affected and unaffected side (Table 1).

Q-angle was measured with a 360° universal goniometer. Patients were positioned standing with both feet parallel, toes pointing forward. The center of the patella, tibial tuberosity, and SIAS were marked. The pivot of the goniometer was placed on the center of the patella. The long arms of the goniometer were placed on the tibial tuberosity and the SIAS. The angle where these lines intersect was regarded as the quadriceps or Q-angle.^[19]

The LDFA and MPTA were measured using weight-bearing anteroposterior radiographs. Radiograph of the lower extremities was taken with bare feet and with the knee in full extension and weight distributed equally over both extremities. Tibial tuberosity was positioned toward the beam. Intra-observer and interobserver reliabilities of the LDFA and MPTA were found to be excellent regardless of the observer's experience.^[20] The LDFA is formed by intersecting the femoral anatomic axis with the tangent to the femoral condyles in the frontal plane (normal range: 85° to 90°).^[21] The MPTA is formed by intersecting the tibial anatomic axis with the tangent to the tibial plateau in the frontal plane (normal range: 85° to 90°).^[21]

Data were analyzed using the SPSS® v14.0 (SPSS Inc., Chicago, IL, USA) software. Paired-sample t-tests were used to investigate differences between the affected and unaffected sides. The association between the Q-angle and radiological measurement was evalu-

Table 1. Differences in Q-angle, LDFA, MPTA, and leg length between the affected and unaffected sides of PFPS patients.

Variables	Affected side (n=85)	Unaffected side (n=85)	p*
	Mean±SD	Mean±SD	
Q-angle (°)	19.61±4.35	17.63± 4.29	0.00
LDFA (°)	81.00± 2.58	81.83± 3.03	0.03
MPTA (°)	87.88± 2.63	87.62± 3.29	0.51
SIAS-MM (cm)	84.57± 5.40	84.45± 5.53	0.20
Trochanter major-MM (cm)	76.75±5.29	76.67± 5.36	0.41

*Paired-sample t-test; statistical significance at $p < 0.05$. LDFA: lateral distal femoral angle, MPTA: medial proximal tibial angle, MM: medial malleolus, SIAS: spina iliaca anterior superior. Statistically significant p values are written in bold.

ated using Pearson's correlation coefficient using two-sided tests. Statistical significance was set at $p < 0.05$.

Results

There was a significant difference in the Q-angle between the affected (19.61 ± 4.35) and unaffected (17.63 ± 4.29) sides ($p = 0.00$) (Table 1). There was a significant difference in the LDFA (81.00 ± 2.58 vs. 81.83 ± 3.03 , $p = 0.03$) and no difference in the MPTA (87.88 ± 2.63 vs. 87.60 ± 3.29 , $p = 0.51$) between the affected and the unaffected side (Table 1). There was no correlation between the Q-angle and LDFA ($r = 0.001$, $p = 0.99$) and MPTA ($r = -0.051$, $p = 0.64$) on the affected side and no correlation between the Q-angle and LDFA ($r = 0.179$, $p = 0.64$) and MPTA ($r = -0.146$, $p = 0.18$) on the unaffected side of the patients.

Discussion

An increased Q-angle (greater than 20°) is a sign of increased lateral patellar displacement.^[1,22] Q-angle intra-rater and inter-rater reliability has varied across studies, with intra-class correlation coefficients reported between 0.20^[19] and 0.70.^[23] Some studies have shown a correlation between the Q-angle and PFPS^[24,25] while other studies did not find any correlation.^[9,17] The varied results of the Q-angle in the literature arise from the subjective nature of the Q-angle measurement technique. Therefore, the relationship between the Q-angle and the onset of PFPS is still unclear. The clinical use of the Q-angle remains doubtful despite being one of the most frequently used and focused parameters in patients with PFPS.

The LDFA and MPTA are commonly used to evaluate lower extremity malalignment.^[8,15] Gordon et al. found excellent interobserver and intra-observer reliabilities for the LDFA and MPTA.^[20] To our knowledge, this is the first study to investigate the relationship between Q-angle and lower extremity malalignment using LDFA and MPTA in women with PFPS.

Increased Q-angle may relate with excessive anterior pelvic tilt, increased femoral anteversion, increased knee valgus, excessive external tibial rotation and foot and patellar position.^[2] Nguyen et al.^[26] investigated the relationship between the Q-angle and lower extremity alignment characteristics (Q-angle, pelvic angle, hip anteversion, tibiofemoral angle, genu recurvatum, tibial torsion, navicular drop and the femur and the tibia length) in healthy subjects. Although a relationship between the Q-angle, increased tibiofemoral angle and increased femoral anteversion were found, there were no significant relationships between the Q-angle and

other parameters (such as pelvic angle, genu recurvatum, tibial torsion, navicular drop, and femur to tibia length ratio). Nguyen et al. evaluated lower extremity alignment parameters using a goniometer.^[26] Moncrieff and Livingston showed lower reliability in Q-angle and tibiofemoral angle measurements than femur length measurement using a digital photographic-goniometric method.^[27] In the present study, radiological measurement was used to determine lower extremity alignment. Patients with PFPS displayed decreased LDFA and increased Q-angle in the affected side while there was no change in the MPTA. LDFA averages were similar while the value of LDFA in the affected side was slightly smaller than the unaffected side. Normal LDFA values range from 85° to 90° .^[8,15] Values lower than 85° reflect valgus deformity and values greater than 90° reflect varus deformity. In the present study, mean LDFA was 81° . The LDFA of 4 patients was 85° or higher in the affected side while the LDFA of 12 patients was 85° or higher in the unaffected side. Our results showed that 95% of valgus deformity in the affected side and 85% of valgus deformity in the unaffected side occurred in patient with PFPS. It is known that Q-angle is related to excessive anterior pelvic tilt, femoral anteversion, knee valgus, and external tibial rotation.^[2] The Q-angle is known to indirectly reflect the degree of valgus translational force exerted upon the patella with contraction of the extensor mechanism of the knee. However, both a favorable and unfavorable relationship between the Q-angle and lateral forces/valgus stress of knee have been reported.^[7,22,28] In addition, while a statistical difference in LDFA between the affected and unaffected side was found in our study, this difference was small (81.00 ± 2.58 vs. 81.83 ± 3.03 , $p = 0.03$). Although LDFA decreased bilaterally, the onset of symptoms and pain in only one side is still a mystery. This result may encourage the use of the terminology 'asymptomatic side' instead of 'healthy side'. We speculated that even minimal changes in the LDFA might cause PFPS. A longitudinal, prospective study on a large, healthy, asymptomatic cohort would help address this speculation.

Despite a decreased LDFA and increased Q-angle, there was no relationship between the Q-angle and LDFA in the present study. The excessive femoral anteversion may relate with the LDFA as a Q-angle. In the present study, femoral anteversion was not evaluated on the radiographs. Excessive femoral anteversion relates with increased knee valgus and causes patellofemoral pain. This is an important study limita-

tion as femoral anteversion is essential. Future studies looking at the relationship between the LDFA and excessive femoral anteversion in patients with PFPS are suggested.

A second limitation of the present study was the lack of an age-matched control group without PFPS. Patients with PFPS in this study did not have any knee pain before the onset of symptoms. Asymptomatic or healthy people may experience pain at some term in their life. To counter this limitation, the asymptomatic sides of the patients were evaluated for comparison.

The final limitation of the study was our inability to prove cause and effect between the PFPS and increased Q-angle. A longitudinal study measuring the femoral anteversion using radiographs of a symptomatic person, toe-in gait analyses and further biomechanical studies are required to determine whether increased Q-angle and excessive femoral anteversion cause PFPS or whether toe-in gait is the result of PFPS.

In conclusion, patients with PFPS showed significantly decreased LDFA and increased Q-angle compared to the asymptomatic side. Further comprehensive biomechanical studies to analyze the relationship between decreased LDFA and excessive femoral anteversion in patients with PFPS are warranted.

Conflicts of Interest: No conflicts declared.

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