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## ■ Original Article

# Relationship between patellar tendon–lateral femoral condyle friction syndrome and patellofemoral instability

## *Patellar tendon – lateral femoral kondil sürtünme sendromu ile patellofemoral instabilite arasındaki ilişki*

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### Abstract

**Aim:** The etiology of the patellar tendon–lateral femoral condyle friction syndrome (PTLFCFS) is not fully known and the number of studies on the diagnosis, treatment, and prognosis of PTLFCFS is limited. The aim of this study was to evaluate the relationship between PTLFCFS and patellofemoral instability in magnetic resonance imaging (MRI).

**Material and Methods:** Six morphological parameters were measured in MRI to evaluate patellofemoral stability in patients with PTLFCFS (study group n = 82) and patients without detection PTLFCFS (control group n = 204) in the knee MRI examination. These parameters include the Insall–Salvati ratio, ventral trochlear prominence, sulcus angle, lateral trochlear inclination angle, patellar inclination angle, and patellar lateralization measurement. In addition, the chondromalacia patella relationship was also evaluated.

**Results:** The Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, and ventral trochlear prominence were significantly higher and lateral trochlear inclination angle was significantly lower in the study group than in the control group. The incidence of chondromalacia patella was significantly higher in the study group. In the study group, there was a positive correlation between the chondromalacia patella and the ventral trochlear prominence.

**Conclusion:** Among the factors causing PTLFCFS, patellofemoral instability was found to be effective. The measured parameters having high sensitivity and specificity suggest that these parameters can be used as risk factors and for the diagnosis.

**Key-words:** Patellar tendon–lateral femoral condyle friction syndrome; patellofemoral instability; magnetic resonance imaging

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## Öz

**Amaç:** Patellar tendon-lateral femoral kondil sürtünme sendromunun (PTLFKSS) etiyolojisi tam olarak bilinmemektedir ve PTLFKSS'unun tanısı, tedavisi ve prognozu ile ilgili çalışmaların sayısı sınırlıdır. Bu çalışmada amacımız PTLFKSS ile patellofemoral instabilite ilişkisini manyetik rezonans görüntüleme (MRG) ile değerlendirmektir.

**Gereç ve Yöntemler:** Diz MRG'sinde PTLFKSS saptanan hastalarda (çalışma grup n=82) ve PTLFKSS saptanmayan hastalarda (kontrol grup n=204) patellofemoral stabiliteyi değerlendirmek için altı morfolojik parametre MRG'de ölçüldü. Bu parametreler Insall-Salvati oranı, ön troklear çıkıntı, sulkus açısı, lateral troklear eğim açısı, patellar eğim açısı ve patellar laterilizasyon ölçümü idi. Ayrıca kondromalazik patella ilişkisi de değerlendirildi.

**Bulgular:** Çalışma grubunda kontrol grubuna göre Insall-Salvati oranı, patellar eğim açısı, patellar lateralizasyon, sulkus açısı ve ön troklear çıkıntı anlamlı olarak daha yüksek ve lateral troklear eğim açısı ise anlamlı olarak daha düşük bulundu. Kondromalazik patella insidansı çalışma grubunda anlamlı derecede yüksekti. Çalışma grubunda kondromalazik patella ile ön troklear çıkıntı arasında pozitif bir korelasyon vardı.

**Sonuç:** PTLFKSS' ye sebep olan faktörler arasında patellofemoral instabilitenin etkili olduğu bulundu. Ölçülen parametrelerin yüksek sensitivite ve spesifiteye sahip olması; bu parametrelerin hem risk faktörü, hem de tanıda kullanılabileceği önerilmektedir.

**Anahtar kelimeler:** Patellar tendon-lateral femoral kondil sürtünme sendromu; patellar insitabilite; manyetik rezonans görüntüleme

## Introduction

The knee is a hinge type joint in which the patellar tendon, ligaments, and sections of fascia lata provide passive stabilization, whereas the quadriceps muscle and aponeurosis provide active stabilization [1]. Excessive movement of the joint is restricted externally by Hoffa (infrapatellar fat pad) and the femoral and tibial condyles [1,2].

Patellar tendon–lateral femoral condyle friction syndrome (PTLFCFS) is considered as one of the leading causes of anterior knee pain, especially seen in young people [3]. Although the etiology of PTLFCFS is not fully known, its pathology is considered to result from the deterioration of knee biomechanics due to previous trauma. Generally accepted view is that the development of inflammation in the Hoffa and the direct contact of the lateral femoral condyle and patellar tendon due to trauma lead to clinical symptoms [1,4].

Magnetic resonance imaging (MRI) is an excellent diagnostic tool for knee imaging. With MRI, all the structures of the knee can be evaluated simultaneously, and this method allows a comprehensive understanding of the causes of anterior knee pain.

In PTLFCFS, an MRI examination shows an increased focal signal to the superolateral of the infrapatellar fat pad due to edema [1,4,5].

The aim of this study was to evaluate the quantitative parameters demonstrating patellofemoral instability of the knee using MRI in patients with PTLFCFS

## Materials and Methods

The ethical compliance of this retrospective study was approved in accordance with the Helsinki Declaration by the Hospital Local Ethics Committee, Ankara, Turkey. Between May 1, 2016, and February 1, 2019, 1542 patients who were admitted to the orthopedics and traumatology department were evaluated. The inclusion criteria were as follows: (1) patients between 18-40 years old; (2) patients who had knee MRI in our radiology database. The exclusion criteria were as follows: (1) a history of major trauma, surgery or arthroscopy, tumor, patellar dislocation, inflammatory knee disease; (2) patients with findings of internal derangement, meniscal pathology, joint effusion; (3) artifacts precluding a proper MRI examination.

Eighty-two patients (18–40 years old) who had for more than 3 weeks due to anterior knee pain and increased focal signal to the superolateral of the infrapatellar fat pad in fat-suppressed proton density-weighted images were evaluated as a study group, whereas 204 patients (23–40 years old) with absence of anterior knee pain and no pathological findings in the superolateral of the infrapatellar fat pad were evaluated as a control group. Quantitative parameters used to evaluate patellofemoral stability were performed in MRI and two groups were compared with each other.

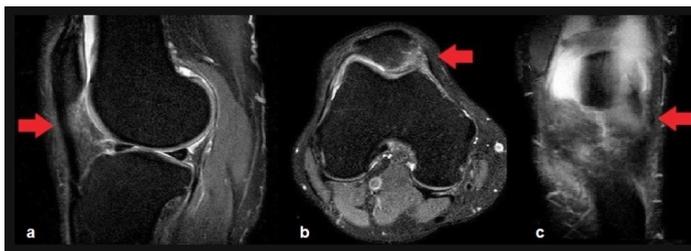
### MRI protocol

MRI examinations were performed using a 1.5 T scanner (Gyrosan Intera, Philips Medical Systems, Nederland B. V.) with a

standard dedicated knee coil. During scanning, the patients were given a supine position with their knees at full extension. The imaging protocol constituted the following five routine sequences: coronal fast spin-echo T1-weighted, sagittal fat-suppressed proton density-weighted, coronal fat-suppressed proton density-weighted, axial fat-suppressed proton density-weighted and sagittal fast spin-echo T2-weighted.

All measurements were conducted by two radiologists, who have a blinded manner for the findings of each other.

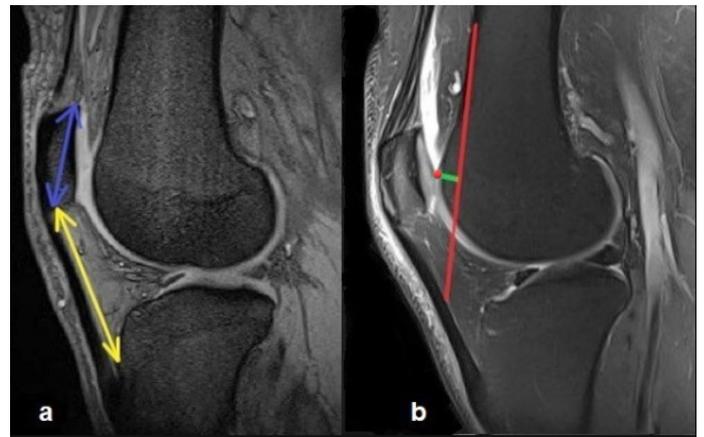
Patients with an increased focal signal to the superolateral of the infrapatellar fat pad in at least two consecutive planes in the sagittal, axial, coronal images were included in the study group. The focal signal increase was considered as positive when it was at least 20% higher than the signal of the neighboring fat pad (1,4,5) (Figure 1 a,b,c).



**Figure 1.** 34-year-old man with anterior knee pain for 4 months. Sagittal (a), axial (b), coronal (c) fat-suppressed proton density-weighted images of the left knee magnetic resonance imaging showing increased focal signal to the superolateral of the infrapatellar fat pad (red arrows). The quantitative parameters were measured manually using the Extreme Picture Archiving and Communications System (PACS) system (Ankara, Turkey) for the study and control groups. All the measurements were performed at the osseous surfaces. Length measurements in millimeters (mm) and angle measurements were made in degrees (°).

**Insall–Salvati ratio:** In the sagittal plane were made from the section where the largest width of the patella was measured. Insall–Salvati ratio is the ratio of the patellar tendon to the patellar length (Figure 2a).

**Ventral trochlear prominence:** In the midsagittal plane were made from the section where the deepest point of the trochlea was measured. Ventral trochlear prominence is the distance between the line paralleling the ventral cortical surface of the distal femur and the most anterior cortical point of the femoral trochlear floor (Figure 2b).



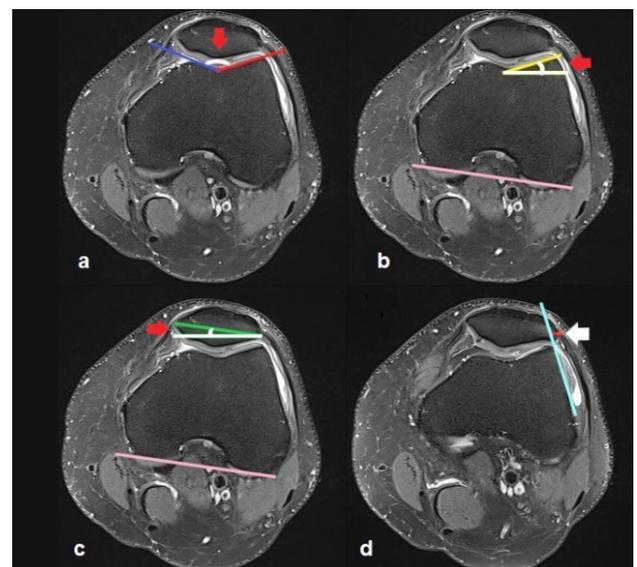
**Figure 2.** Sagittal magnetic resonance images shows; (a) Insall–Salvati ratio: Patellar tendon length (yellow line)/Patellar length (blue line), (b) Ventral trochlear prominence: is the distance (green line) between the line paralleling the ventral cortical surface of the distal femur (red line) and the most anterior cortical point of the femoral trochlear floor (red point).

**Sulcus angle:** In the axial plane, it was assessed 3 cm above the tibiofemoral joint line. The sulcus angle is formed by the lowest point of the intercondylar sulcus and the highest points of the medial and lateral femoral condyles. (Figure 3a).

**Lateral trochlear inclination angle:** is the angle between the line passing through the lateral trochlear facet and the tangent line crossing the posterior condyles (Figure 3b).

**Patellar inclination angle:** It is an angle between the patellar axis (between medial and lateral articular margins of patella) and the tangent line crossing the posterior condyles (Figure 3c).

**Patellar lateralization (patellar lateral lateralization):** The patellar lateralization is the distance between the most lateral point of the patella and the lateral margin of the trochlea (Figure 3d).



**Figure 3.** Axial magnetic resonance images shows; (a) Sulcus angle: The angle (red arrow) between the medial femoral condyle (blue line) and the lateral femoral condyle lines (red line), (b): Lateral trochlear



inclination angle: The angle (red arrow) between the line passing through the lateral trochlear facet (yellow angle) and the tangent line crossing the posterior condyles (pink line), **(c)** Patellar inclination angle (tilt): The angle (red arrow) between the patellar axis (green line) and the tangent line crossing the posterior condyles (pink line), **(d)** Patellar lateralization (patellar lateral lateralization): is the distance (red line) between the most lateral point of the patella (white arrow) and the lateral margin of the trochlea (turquoise line).

The relationship between patellofemoral instability and the chondromalacia patella was also evaluated using the same parameters. Chondromalacia patella type was evaluated using MRI-adapted Outerbridge classification for chondral defects. The patients with multiple cartilage injuries were classified according to the most serious injury.

Grade 1: Focal hyperintense areas with normal contour

Grade 2: Blister-like swelling/fraying of articular cartilage extending to the surface

Grade 3: Partial cartilage thickness loss with focal ulceration

Grade 4: Full cartilage thickness loss and reactive change in the bone.

### Statistical analysis

Data were analyzed using Statistical Package for the Social

Sciences (SPSS) software (IBM SPSS 25.0, IBM Corporation, Armonk, NY, USA). The data were analyzed using Kolmogorov-Smirnov for normal distribution. The Mann-Whitney U test (non-parametric) was used for analysis because the data did not conform to a normal distribution. Spearman (nonparametric) correlation test was used for correlation among the groups. Pearson's Chi-Square test was used for the analysis of categorical variables. Receiver operating characteristic (ROC) curve analysis was used to calculate the cut-off value (cut-off), specificity and sensitivity of the data. Mean and standard deviation values were used for analysis.  $P < 0.05$  was considered statistically significant.

### Results

The mean age of the patients was  $23.61 \pm 2.94$  years, and 51.2% of the patients were males. No difference was found between the study and control groups in terms of age and gender ( $p > 0.05$ ) (Table 1). In our study, the Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, and ventral trochlear prominence were significantly higher and lateral trochlear inclination angle was significantly lower ( $p < 0.05$ ) in the study group than in the control group (Table 1). The incidence of chondromalacia patella was also significantly higher in the study group ( $p < 0.05$ ) (Table 1).

**Table 1.** Comparison of the demographic and quantitative parameters of the study and control groups

		Study group (n=82) Mean±SD/n (%)	Control group (n=204) Mean±SD/n (%)	p*
Age		23,61±2,94	23,73±3	0,534
Gender	Male	42 (51,2)	105 (51,5)	0,969*
	Female	40 (48,8)	99 (48,5)	
Insall–Salvati ratio		1,33±0,05	1,25±0,14	<0,001
Patellar inclination angle (°)		24,76±6,94	8,51±2,13	<0,001
Patellar lateralization (mm)		7,81±3,13	0,71±1,12	<0,001
Sulcus angle (°)		140,4±5,9	119,22±3,91	<0,001
Lateral trochlear inclination angle (°)		14,61±4,19	27,28±3,51	<0,001
Ventral trochlear prominence (mm)		8,4±1,01	6,65±0,75	<0,001
Chondromalacia patella	Normal cartilage	33 (40,2)	159 (77,9)	<0,001*
	1	15 (18,3)	15 (7,4)	
	2	10 (12,2)	14 (6,9)	
	3	12 (14,6)	9 (4,4)	
	4	12 (14,6)	7 (3,4)	

SD = standard deviation, \* Mann-Whitney U test, \*\* Pearson's Chi-Square test were used for statistical analysis

In both study and control groups, chondromalacia patella was found to be positively correlated with Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, and ventral trochlear prominence, whereas chondromalacia patella was found to be negatively correlated with lateral trochlear inclination angle ( $p < 0.05$ ). In the study group, there

was a positive correlation between the chondromalacia patella and the ventral trochlear prominence ( $p < 0.05$ ), whereas no correlation was found between the chondromalacia patella and the Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, and lateral trochlear inclination angle ( $p > 0.05$ ) (Table 2).

**Table 2.** The relationship between chondromalacia patella and quantitative parameters

	Study and control groups (n:286)		Study group (n:82)	
	r	p*	r	p*
Insall–Salvati ratio	0,212	<0,001	0,074	0,507
Patellar inclination angle (°)	0,296	<0,001	-0,038	0,738
Patellar lateralization (mm)	0,365	<0,001	0,013	0,910
Sulcus angle (°)	0,271	<0,001	-0,127	0,256
Lateral trochlear inclination angle (°)	-0,346	<0,001	0,005	0,964
Ventral trochlear prominence (mm)	0,313	<0,001	0,242	0,028

\*Spearman correlation test was used for statistical analysis

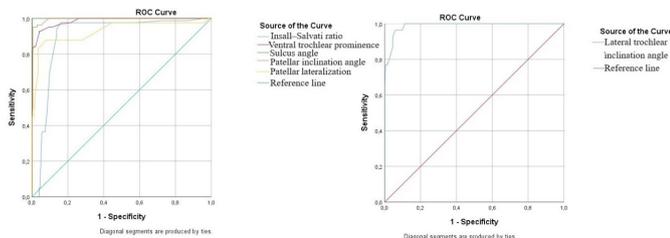
The sensitivity, specificity, area under the curve and cut-off values for the Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, lateral trochlear inclination

angle, and ventral trochlear prominence are shown in Figure 4 and Table 3.

**Table 3.** Sensitivity, specificity, area under the curve, and cut-off values of the quantitative parameters

Test Result Variable(s)	AUC	Cut-off	Sensitivity	Specificity	Asymptotic 95% Confidence Interval	
					Lower Bound	Upper Bound
					0,859	0,940
Patellar inclination angle (°)	1,000	11,6	%100	%100	1,000	1,000
Patellar lateralization (mm)	0,986	2,45	% 95,1	% 90,7	0,976	0,997
Lateral trochlear inclination angle (°)	0,988	21.3	%96,3	%94,1	0,980	0,996
Sulcus angle (°)	0,995	127,5	%96,3	%97,1	0,989	1,000
Ventral trochlear prominence (mm)	0,929	7,65	%87,8	%92,2	0,889	0,969

AUC= area under the curve



**Figure 4.** ROC analysis of the quantitative parameters.

## Discussion

PTLFCFS is a disease typically characterized by anterior knee pain that emerges with activity [1]. In the literature, the number of studies on the diagnosis, treatment, and prognosis of PTLFCFS is limited.

In the present study, the Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, and ventral trochlear prominence increased significantly in the study group, whereas the lateral trochlear inclination angle was found to be significantly lower than in the control group. In addition to the quantitative parameters in the literature, to our knowledge, ventral trochlear prominence was measured for the first time in the present study for the diagnosis of PTLFCFS and we found a positive correlation between ventral trochlear promi-

nence. And the incidence of chondromalacia patella was significantly higher in the study group and there was a positive correlation between the chondromalacia patella and the ventral trochlear prominence.

Studies in the literature have reported that biomechanical changes cause this syndrome in young patients under the age of 40 [4,6]. Subhawong et al. evaluated the quantitative parameters measured in patients with PTLFCFS with respect to gender and age and found no statistically significant difference [7]. Consistent with the literature, the patients in the present study were young; 51.2% of the patients were males, and both age and gender were similar to that of the control group [7]. We consider that the incidence of pathology is higher in young people than in elderly due to the fact that young people perform activities that constantly operate the knee joint [sports, training, etc.]; chondromalacia patella is common in young people, and the knee is more frequently exposed to trauma. We consider that the pathology is similarly common in both genders due to the fact that both genders are at similar risk.

Munch et al. found that an increased level of patellar height leads to greater knee instability [8]. Matcuk et al. found that the Insall–Salvati ratio was higher in patients with PTLFCFS



than those without PTLFCFS and stated that high index rates could be considered as a risk factor [3]. Widjajahakim et al. reported a significant correlation between superolateral Hoffa fat pad edema and the Insall–Salvati ratio [9]. Bonadio et al. stated that a high patella leads to more tension of the patellar tendon during knee movements and that this can easily cause compression of the bursa between the lateral femoral condyle [10]. Consequently, inflammation can develop in the Hoffa and lead to edema and pain [10]. Li et al. found that the Insall–Salvati ratio rate was high in patients with PTLFCFS and that the sensitivity and specificity were 82% and 96.6%, respectively, at a cut-off value of 1.20 [1]. In the present study, the Insall–Salvati ratio was found to be significantly higher in the study group than in the control group. We believe that the patellar tendon is stretched and the structures underneath are compressed during knee flexion in patients with a high Insall–Salvati ratio. We also believe that inflammation and pain develop in the region in response to this.

It has been reported that the patellar inclination angle is the source of anterior knee pain in patients without clinical instability or clinical history. A patellar inclination angle of more than  $13^\circ$  has been reported to be a risk factor [4,11]. Matcuk et al. and Barbier–Brion et al. found that patellar inclination angle was significantly higher in patients with PTLFCFS [3,4]. In the present study, the patellar inclination angle was found to be significantly higher in the study group than in the control group. Patellar inclination angle exceeding the cut-off value may have led to the volume on the posterior side of the patella to be reduced and the posterior side of the patella to not sit properly on the joint.

Barbier–Brion et al. stated that patellar lateralization was significantly higher in the PTLFCFS group than in the control group and calculated sensitivity and specificity for a cut-off value of 6 mm as 75% and 83%, respectively [4]. Patellar lateralization was found to be significantly higher in the study group in the present study. Lateral displacement of the area where the posterior surface of the patella sits may have facilitated PTLFCFS by disturbing joint stabilization.

Matcuk et al. and Subhawong et al. described that the sulcus angles of patients with PTLFCFS were similar to those of the control group [3,7]. However, Gürsoy et al. reported that the sulcus angle was significantly higher in the PTLFCFS group compared with the control group [12]. Widjajahakim et al. reported that superolateral Hoffa fat pad edema was not associated with the sulcus angle [9]. In the present study, the sulcus

angle of the study group was significantly higher than that in the control group. We believe that flattening the sulcus angle of the tibia may have caused damage by increasing the compression on the bursas of the triangular cartilage structure on the posterior side of the patella.

Matcuk et al. reported that the lateral trochlear inclination angle was lower in patients with PTLFCFS and that angles  $<11^\circ$  were associated with high risk [3]. Li et al. found that the lateral trochlear inclination angle was low in patients with PTLFCFS and that sensitivity and specificity were 98.9% and 32%, respectively, for a cut-off value of 16.3 [1]. Gürsoy et al. found a decrease in the lateral patellofemoral angle [12]. Barbier–Brion et al. found that the lateral trochlear inclination angle was similar between the patient and control groups [4]. Widjajahakim et al. reported that superolateral Hoffa fat pad edema was not associated with the lateral trochlear inclination angle [9]. In the present study, the lateral trochlear inclination angle was found to be low. We believe that the decrease in the lateral trochlear inclination angle leads to an increase in the sulcus angle, thereby increasing the contact with the lower surface of the patella. Consequently, the structures under the patella remain under compression, leading to increased friction on the lower face of the patella.

Widjajahakim et al. described that anterolateral shifts increase the risk of Hoffa edema [9]. Barbier–Brion et al. reported that trochlear dysplasia increased the prevalence of PTLFCFS [4]. In the present study, ventral trochlear prominence significantly increased in the study group, and a positive correlation was found between the ventral trochlear prominence and the level of chondromalacia patella. Large ventral trochlear prominence may have increased the risk of PTLFCFS, as it may lead to the deterioration of knee joint instability and the stretching of the patella ligament. We believe that as the amount of cartilage damage behind the patella increases and the amount of edema in the Hoffa fat pad also increases in a correlated manner, leading to an increase in the ventral trochlear prominence. This may have led to an increase in the prevalence of PTLFCFS by increasing knee instability.

Various sensitivity and specificity values have been reported in the literature for different angles and lengths [1,4]. In the present study, sensitivity and specificity rates for appropriate cut-off values for current angles and lengths were found to be 87.8%–100% and 84.8%–100%, respectively. The high sensitivity and specificity values suggest that changes in existing angle and length values may be used both as risk factors and diagnostic purposes.

Chondromalacia patella is characterized by damage to the knee joint cartilage and leads to instability. In their study, Gürsoy et al. reported that the patellar shift in patients with chondromalacia patella and lateral patellofemoral angles was similar to that in patients without chondromalacia patella, whereas trochlear depth was shorter, sulcus angle was wider, and the Insall–Salvati ratio was higher [12]. In the present study, it was found that the prevalence of PTLFCFS increased in patients with chondromalacia patella. In the entire sample, a positive correlation was found between the Insall–Salvati ratio, patellar inclination angle, patellar lateralization, sulcus angle, and ventral trochlear prominence, whereas a negative correlation was found among the lateral trochlear inclination angle. Joint instability caused by chondromalacia patella, increased pressure on the bursas, especially the Hoffa, and increased inflammation may have led to an increase in the prevalence of PTLFCFS. In relation to the increase in the chondromalacia patella, we think that the instability of the knee is further deteriorated and that the inflammation is further exacerbated.

The major limitation of this retrospective study was the fact that radiologists who evaluated the parameters simultaneously determined the presence of the increased focal signal to the superolateral of the infrapatellar fat pad. Second, the diagnosis of articular cartilage damage in these patients could not be confirmed by any gold standard method, such as arthroscopy and surgery.

## Conclusion

Patellofemoral instability was found to be effective among the factors causing PTLFCFS. The Insall–Salvati ratio, ventral trochlear prominence, sulcus angle, lateral trochlear inclination angle, patellar inclination angle, and patellar lateralization of the study group were found to be different than those of the control group. In addition, high sensitivity and specificity values identified for these parameters indicate that these parameters may be used both as a risk factor and for diagnostic purposes.

## Declaration of conflict of interest

The authors received no financial support for the research and/or authorship of this article. There is no conflict of interest.

## References

1. Li J, Sheng B, Yu F, Guo C, Lv F, Lv F, Et Al. Quantitative Magnetic Resonance Imaging In Patellar Tendon-Lateral Femoral Condyle Friction Syndrome: Relationship With Subtle Patellofemoral Instability. *Skeletal Radiol* 2019; 48: 1251-59.
2. Fontanella Cg, Carniel El, Frigo A Et Al. Investigation Of Biomechanical Response Of Hoffa's Fat Pad And Comparative Characterization. *J Mech Beh Biomed Mater* 2017; 67: 1-9.
3. Matcuk Jr Gr, Cen Sy, Keyfes V, Patel Db, Gottsegen Cj, White Ea. Superolateral Hoffa Fat-Pad Edema And Patellofemoral Maltracking: Predictive Modeling. *Ajr Am J Roentgenol*. 2014; 203: 207-12.
4. Barbier-Brion B, Lerais J-M, Aubrey S, Lepage D, Vidal C, Delabrousse E Et Al. Magnetic Resonance Imaging In Patellar Lateral Femoral Friction Syndrome (Plffs): Prospective Case-Control Study. *Diagn Interv Imaging* 2012; 93: 171-82.
5. Chung Cb, Skaf A, Roger B, Campos J, Stump X, Resnick D. Patellar Tendon–Lateral Femoral Condyle Friction Syndrome: Mr Imaging In 42 Patients. *Skeletal Radiol* 2001; 30: 694-97.
6. Jibri Z, Martin D, Mansour R, Kamath S. The Association Of Infrapatellar Fat Pad Oedema With Patellar Maltracking: A Case–Control Study. *Skeletal Radiol* 2012; 41: 925-31.
7. Subhawong Tk, Thakkar Rs, Padua A, Flammang A, Chhabra A, Carrino Ja. Patellofemoral Friction Syndrome: Mri Correlation Of Morphologic And T2 Cartilage Imaging. *J Comput Assist Tomogr* 2014; 38: 308-12.
8. Munch JI, Sullivan Jp, Nguyen Jt, Mintz D, Green Dw, Shubin Stein Be Et Al. Patellar Articular Overlap On Mri Is A Simple Alternative To Conventional Measurements Of Patellar Height. *Orthop J Sports Med* 2016; 4: 2325967116656328.
9. Widjajahakim R, Roux M, Jarraya M, Roemer Fw, Neogi T, Lynch Ja Et Al. Relationship Of Trochlear Morphology And Patellofemoral Joint Alignment To Superolateral Hoffa Fat Pad Edema On Mr Images In Individuals With Or At Risk For Osteoarthritis Of The Knee: The Most Study. *Radiology* 2017; 284: 806-14.
10. Bonadio Mb, Helito Cp, Do Prado Torres Ja, Gobbi Rg, Pécora Jr, Camanho Gl Et Al. Plateau–Patella Angle: An Option For The Evaluation Of Patellar Height In Patients With Patellar Instability. *The Knee* 2017; 24: 340-44.
11. Campagna R, Pessis E, Biau Dj, Guerini H, Feydy A, Thevenin Fs Et Al. Is Superolateral Hoffa Fat Pad Edema A Consequence Of Impingement Between Lateral Femoral Condyle And Patellar Ligament? *Radiology* 2012; 263: 469-74.
12. Gürsoy M, Mete Bd, Oyar O, Erdoğan N, Uluç Me, Bulut T Et Al. The Association Of Patellar Maltracking With Infrapatellar Fat Pad Edema And Chondromalacia Patella: A Quantitative Morphological Magnetic Resonance Imaging Analysis. *Turk J Phys Med Rehab* 2018; 64: 246-52.