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Severity of subchondral insufficiency knee fracture: is it associated with increasing age, femorotibial angle, and severity of meniscus extrusion?

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ABSTRACT

Aim: To evaluate the relationship between severity of subchondral insufficiency fracture of the knee (SIFK) and age, gender, knee alignment, meniscus tear, type and location, severity of meniscus extrusion, and degree of knee osteoarthritis.

Material and Method: This retrospective study included 308 patients with SIFK seen on MRI. SIFK lesions were categorized as grade 1 to 4, with distinction between low grade (1 and 2) and high grade (3 and 4). The relationships between SIFK grade and patients' age, body mass index (BMI), femorotibial angle (FTA), meniscus tear,type and location meniscusextrusiongrade and osteoarthritis (grade 0 to grade 4) evaluated.

Results: According to the gender, 39.3% were men and 60.7% were women. The distrubutin of the SIFK grades were respectively 42.2% grade 1, 30.8% grade 2, 22.7% grade 3 and 4.2% grade 4. FTAwas positively correlated with SIFK grade (from grade 1 to grade 4, respectively; 4.42±2.57, 5.09±2.26, 5.74±2.78 and 5.95±2.54) (p=0.002). No statistically significant difference was observed between height, weight and BMI and the degree of SIFK.The mean FTA was 4.99±2.57° in SIFK. The FTA angles showed a stastistically significance between low (4.73±2.48°) and high (5.71±2.69°)grade SIFK (p:0.003). Roc analysis showed that the FTA above 3.1° and the age above 52 year old were at risk. The mean extent of meniscal extrusion was larger in high grade SIFK (p=0.001). Multivariable logistic regression analysis showed that compared with low grade SIFK, high grade SIFK was more closely associated with age, FTA, lateral meniscus extrusion and medial meniscus tear type.

Conclusion: High-grade SIFK lesions are associated with higher FTA and older age. In particular, patients with acute knee pain, older than 52 years of ageanda higher FTA than 3.1°, we recommend to perform knee MRI if possible.

Keywords: SIFK, subchondral insufficiency fracture, meniscus extrusion, osteoarthritis

INTRODUCTION

Subchondral insufficiency fracture of the knee (SIFK) is a type of stress fracture that results in recurrent physiological or excessive stress-related micro-fractures in the subchondral bone of the knee joint (1). The SIFK lesion localizes at epiphysis of the knee joint (2). In SIFK lesion, patients usually present with knee pain with an acute onset and clinically lasting for several months, usually without trauma or with only minor trauma.

SIFK was first described by Ahlbäck et al. he named it “spontaneous osteonecrosis of the knee (SONK)” in 1968 (3). Yamamoto et al. (4) reported that the true nature of SONK is a subchondral fracture. If the subchondral fracture does not heal and eventually transforms into osteonecrosis, as a result osteochondral collapse occurs (4-7).

Although the pathological mechanism has not been fully elucidated, it has been suggested that intramedullary edema-like bone marrow signal intensity associated with subchondral microfractures, increased intraosseous pressure and decreased local blood circulation may play a role in the development of osteonecrosis (8). It is now widely accepted that SONK is the final stage of subchondral fracture and is part of the advanced stage of the SIFK spectrum (1).

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Fracture line and early-stage lesions in SIFK are often unclear on radiographs. As the lesion progresses, radiographic abnormalities become visible, including osteochondral defects or deformities of the epiphyses (9,10). In 1979 Koshino et al. proposed a clinical classification system for SONK based on symptoms and radiographic findings (11). The Koshino classification is still often used as a reference to determine treatment strategies. In 2019, Seyyid et al. (12) proposed a grading system based on MRI. A hypointense line on T2 sections in the affected condyle-subchondral region, diffuse bone marrow edema-like signal intensity, is the characteristic finding on MRI for the diagnosis of SIFK (12). The etiology of SIFK is considered to be multifactorial (1). Various risk factors and associated findings for SIFK have been reported to date (1). Excessive contact stress due to cartilage and meniscal injury plays an important role in the development of SIFK (1). The aim of the study was to evaluate the relationship between severity ofSIFKand age, gender, knee alignment, meniscus tear/type/location, severity of meniscus extrusion, and degree of knee osteoarthritis.

MATERIAL AND METHOD

The study was carried out with the permission of Tokat Gaziosmanpaşa University Hospital Ethics Committee (Date: 2022, Decision No: 22-KAEK-019). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

This retrospective study performed at Tokat Gaziosmanpasa Universty. From January 2011 to December 2020 in our hospital, MRI data including the knee region for any reason were analyzed using the electronic patient record system. The picture archiving and communication system (PACS) program was used for all reconstructions and measurements (Sectra Workstation IDS7, Version 21.2.11.6289, ©2019 Sectra AB).

The available knee MRIs in the PACS system were screened for SIFK. The patients included in the study were those who were unanimously diagnosed with SIFK on MRI by two orthopedic physicians with at least 10 years of experience. The age,weight,height, body mass index (BMI) were recorded. The exclusion criteria were the patients with MRI images taken after an acute event associated with high-energy trauma, fracture or high-grade contusion, patients who did not have MRI images of a quality that could evaluate SIFK, patients who underwent surgical intervention such as meniscectomy in the knee, patients with infection in the knee region or patients with tumors were excluded from the study.

As described in previous studies, the SIFK evaluated using T2-fat suppression MRI based on MRI findings (12). In this study, a previously proposed MRI grading system for SIFK was used to help identify factors that may be associated with high-grade (HG) and low-grade (LG) SIFK (12) (**Figure 1**). The exact place of the SIFK lesion was classified as coronal (medial, central, lateral) and sagittal (anterior, middle, posterior).

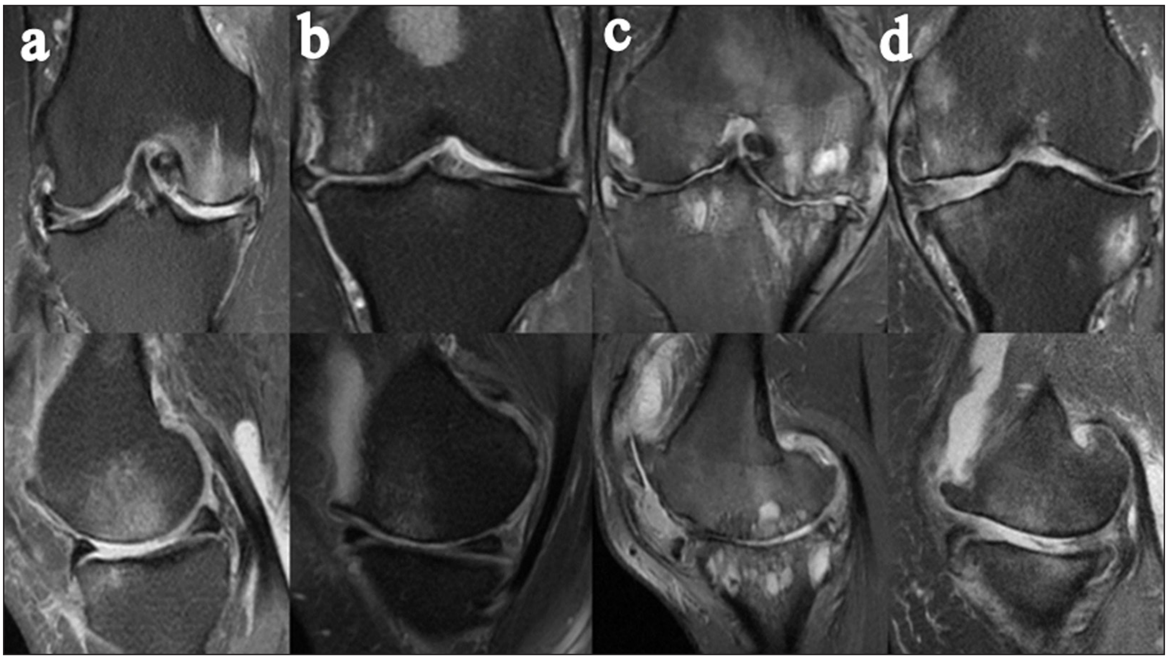

Figure 1: Sıfk grading; a) Grade 1: In MRI, there is a change in bone marrow signals like edema and there is no obvious fracture line. b) Grade 2: Subchondral fracture. c) Grade 3: Subchondral fracture with cystic changes. d) Grade 4: Subchondral collapse accompanied by subchondral fracture

Extruded or unextruded meniscal tears (medial or lateral) were detected on coronal fat-suppressed T2-weighted sequences. Meniscal tears and extrusions were classified as none, mild (<3 mm), moderate (3–5 mm), or severe (>5 mm) (13-15). Meniscal tears (medial or lateral) with or without extrusions were identified on the coronal and fat suppressed T2-weighted sequences. Also MRIs were scanned for additional medial and lateral meniscal tear to the knee accompanying meniscus root injury. The type of tear was recorded.

A mid-coronal plane was used to assess meniscus extrusion (16,17). The middle coronal plane, the section with the most prominent medial tibial eminence or the section with the maximum width of the tibial plateau were selected (16,17) (**Figure 2**). Osteoarthritis (OA) grade was described in the medial and lateral knee compartments. Medial and lateral knee compartments OA were classified according to The International Cartilage Repair Society (ICRS) MRI-based grading system (18). The degree of OA was defined separately in the medial and lateral knee compartments. The MRI-based The International Cartilage Repair Society (ICRS) grading system was used to classify the degree of OA (18).

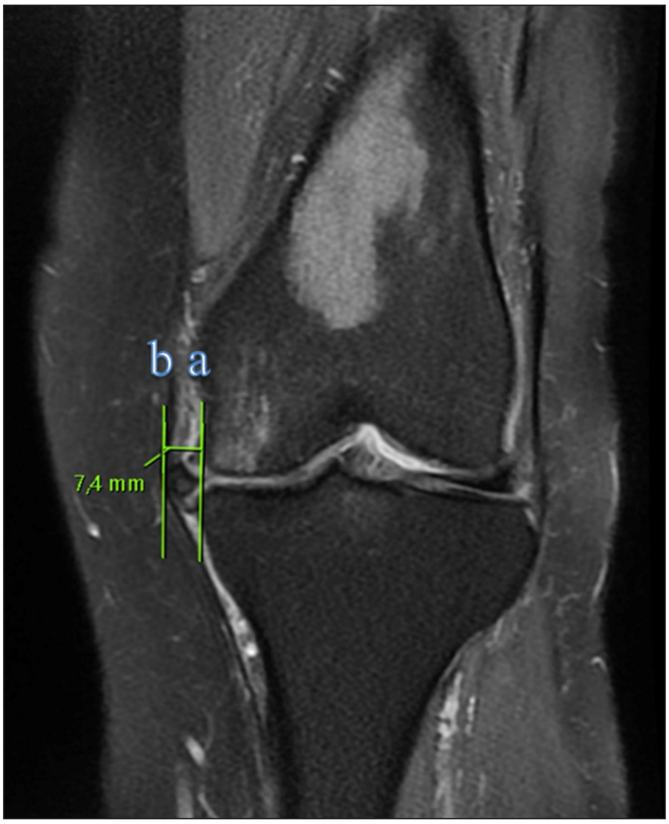

Figure 2: Measurement of medial meniscal extrusion. Extrusion is determined by measuring the distance in mm between the two perpendicular lines in the image showing the femoral medial condyle. First, a proper slice is selected in the coronal plane magnetic resonance imaging. Second, the exclusion of osteophytes are performed. Third, a perpendicular line (a) is drawn at a point at which the medial tibial plateau transitions from horizontal to vertical, then another perpendicular line (b) is drawn intersecting the outermost edge of the medial meniscus. The distance between the lines (a) and (b) is measured.

To avoid additional doses of radiation to patients, the FTA was measured using MRI images. The FTA was measured according to the method described by Iranpour-Boroujeni et al. (19). First, the mid-coronal axis is found. Second, a line connecting the condyles is drawn. Third, a line is drawn perpendicular to the line joining the condyles and the midpoint of these perpendiculars is found. Then, the alignment angle which is a negative number for valgus is calculated (**Figure 3**) (19).

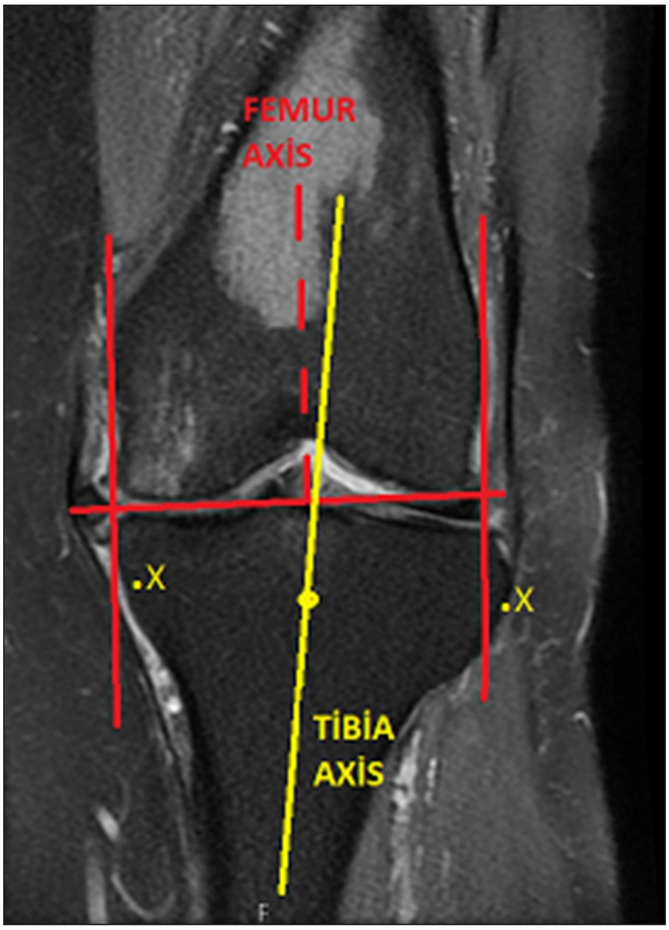

Figure 3: Determination of the femur tibial angle by the method proposed by Iranpour-Boroujeni et al. In the method, first, the mid-coronal axis is found, second, a line connecting the condyles is drawn. Third, a line is drawn perpendicular to the line joining the condyles and the midpoint of these

Statistical Analysis

Data are expressed as mean±standard deviation or frequency and percent. Independent sample t test or one way analysis of variance were used to compare the continuous normal data between/among groups. Chi-Square test was used to compare the categorical data between/among groups. Categorical variables were presented as a count and percentage.Receiver operating characteristic (ROC) analysis was applied to determine the power of variables in predicting significant SIFK classification. A p-value <0.05 was considered significant. Analyses were performed using SPSS 19 (IBM SPSS Statistics 19, SPSS inc., an IBM Co., Somers, NY).

RESULT

After applying the inclusion and exclusion criteria, SIFK was identified in a total of 308 patients on knee MR imaging.Low grade SIFC was found in 225 patients, while high grade SIFC was found in 83 patients.The majority of SIFK lesions are low grade (LG; 73.1%).The rate of women (60.7%) was higher in patients with SIFK. In MRI, SIFK was most common in the central region (C), that is, in the most load-bearing area of the knee, both in the coronal (63.6%) and sagittal planes (52.9%). Meniscal tear was more common in the medial (39.9%) compartment.Medial meniscus(MM) root tear was detected in 25% of the patients.Grade 1 arthrosis was seen in 43.8% in the lateral compartment and in 26.9% in the medial compartment. While the rate of Grade 3 MKOA was 34% in those with high-grade SIFK, the rate of Grade 1 MKOA was 30.2% in those with low-grade SIFK. The degree of arthrosis in the medial compartment increased as the SIFK degree increased (p<0.001).Demographic data are given in **Table 1**.

The mean age of the patients participating in the study was 57.2±12.2 years and the mean BMI was 26.34±2.45 kg/m² (**Table 2**). High grade SIFK patients were older than the other patients. MM extrusion and FTA were higher in high grade SIFK patients compared to other patients.The mean FTA was 4.99±2.57 degrees varus. This explained that OA is more common medially. FTA was higher in patients with high grade SIFK (5.71±2.69) (p=0.003). A similar BMI was found between LG and HG SIFK lesions (26.37±2.37, 26.23±2.72, respectively)(**Table 2**).

Low grade SIFK MM extrusion was 1.95±2.55 mm, while high grade SIFK MM extrusion was 3.16±2.73 mm (**Table 2**). MM extrusion degree increased as the SIFK degree increased (p<0.001).While there was no statistically significant difference between the SIFK groups in terms of height, weight and BMI, there was a difference between numerical variables such as age, FTA, and meniscus extrusion (**Figure 4**).

Table 2. Distribution of numericalvariablessuch as age, weight, BMI, femorotibialangle, meniscusextrusionaccordingtothe SIFK system

Variables	Total	SIFK gradingsystem		p
		Lowgrade Mean±SS	High grade Mean±SS	
Age yıl	57.26±12.22	55.76±12.76	61.34±9.54	<0.001
Weight cm	73.13±7.05	73.15±6.95	73.07±7.34	0.860
Height kilogram	1.67±0.04	1.67±0.04	1.67±0.04	0.561
BMI	26.34±2.45	26.35±2.36	26.3±2.69	0.663
FTA	4.99±2.57	4.73±2.48	5.71±2.69	0.003
Medial meniscus extrusion(mm)	2.27±2.65	1.95±2.55	3.16±2.73	<0.001
Lateral meniscus extrusion(mm)	1.14±2.22	1.04±2.29	1.42±2	0.183

Independent samples t test was used

Table 1. Distribution of demographicdataby SIFK system

Variables	Total	SIFK grading system		p
		Low grade n (%)	High grade n (%)	
Gender				0.140
Female	187 (60.7)	131 (58.2)	56 (67.5)	
Male	121 (39.3)	94 (41.8)	27 (32.5)	
Lateralization				0.229
Left	172 (55.8)	121 (53.8)	51 (61.4)	
Right	136 (44.2)	104 (46.2)	32 (38.6)	
Lateral compartman arthrosis (LKOA)				<0.001
None	63 (20.5)	43 (19.1)	20 (24.1)	
Grade 1	135 (43.8)	116 (51.6)	19 (22.9)	
Grade 2	63 (20.5)	36 (16)	27 (32.5)	
Grade 3	28 (9.1)	17 (7.6)	11 (13.3)	
Grade 4	19 (6.2)	13 (5.8)	6 (7.2)	
Medial compartman arthrosis (MKOA)				<0.001
None	47 (15.3)	37 (16.4)	10 (12)	
Grade 1	83 (26.9)	68 (30.2)	15 (18.1)	
Grade 2	81 (26.3)	64 (28.4)	17 (20.5)	
Grade 3	59 (19.2)	30 (13.3)	29 (34.9)	
Grade 4	38 (12.3)	26 (11.6)	12 (14.5)	
SIFK Location on coronal plane				0.021
(P)1	88 (28.6)	74 (32.9)	14 (16.9)	
(C)2	196 (63.6)	134 (59.6)	62 (74.7)	
(I)3	24 (7.8)	17 (7.6)	7 (8.4)	
SIFK Location on sagittal plane				0.724
(A)1	29 (9.4)	20 (8.9)	9 (10.8)	
(C)2	163 (52.9)	122 (54.2)	41 (49.4)	
(P)3	116 (37.7)	83 (36.9)	33 (39.8)	
Locationof meniscal tear compartment of knee				<0.001
None	76 (24.7)	70 (31.1)	6 (7.2)	
Medial	123 (39.9)	84 (37.3)	39 (47)	
Lateral	9 (2.9)	7 (3.1)	2 (2.4)	
Both	100 (32.5)	64 (28.4)	36 (43.4)	
Medialmeniscus tear type				<0.001
None	87 (28.2)	79 (35.1)	8 (9.6)	
Root	77 (25)	50 (22.2)	27 (32.5)	
Radial	27 (8.8)	13 (5.8)	14 (16.9)	
Other	117 (38)	83 (36.9)	34 (41)	
Lateralmeniscus tear type				0.038
None	198 (64.3)	154 (68.4)	44 (53)	
Root	3 (1)	2 (0.9)	1 (1.2)	
Vertical	1 (0.3)	0 (0)	1 (1.2)	
Other	106 (34.4)	69 (30.7)	37 (44.6)	
Medial meniscus extrusion group				0.001
None	144 (46.8)	118 (52.4)	26 (31.3)	
Mild	50 (16.2)	37 (16.4)	13 (15.7)	
Moderate	58 (18.8)	40 (17.8)	18 (21.7)	
Severe	56 (18.2)	30 (13.3)	26 (31.3)	
Lateral meniscus extrusion group				<0.001
None	228 (74)	179 (79.6)	49 (59)	
Mild	22 (7.1)	10 (4.4)	12 (14.5)	
Moderate	31 (10.1)	14 (6.2)	17 (20.5)	
Severe	27 (8.8)	22 (9.8)	5 (6)	

Pearson chi-square test was used.

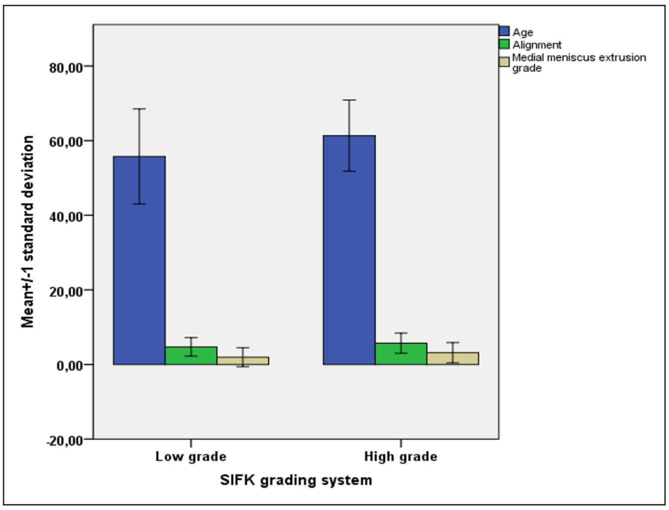

Figure 4: Figure bar graph with mean+/-1 standard deviaton of variables by SIFK grading system

While 16.9% of high-grade SIFKs were radial meniscus tears and 32.5% of them were meniscus root tears, this rate was lower in low-grade SIFKs. There was a significant difference between the SIFK groups in terms of MM extrusion (**Figure 5**). While there was no MM extrusion in 31.3% of high-grade SIFCs, this rate was higher in low-grade SIFKs (52.4%).

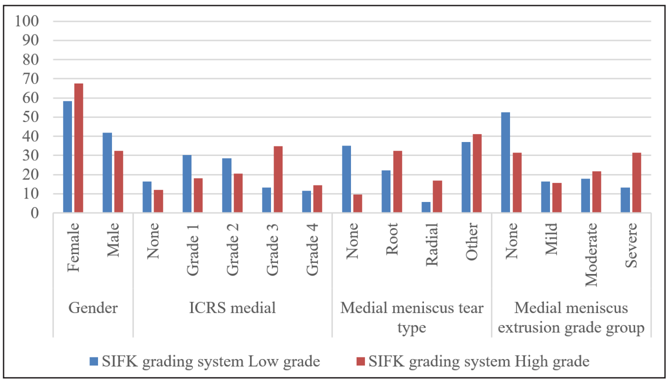

Figure 5: Accordingtothe SIFK grading system, age, medial compartment arthrosis, medial meniscus tear type, classification of medial meniscus extrusion

If we evaluate the Classification of SIFK, grade 1, grade 2, grade 3, grade 4 separately, there was a significant difference in terms of lateral compartment OA, medial compartment OA, SIFK location on coronal plane, location of meniscal tear compartment of knee, MM tear type, lateral meniscus (LM) tear type, MM extrusion grade and LM extrusion grade (**Table 3**). Among all SIFK groups, SIFK Grade 1 was the highest (42.2%) (**Table 3**).

The mean age of grade 4 SIFC was 61.5±5.01 years, and the mean age of grade 1 SIFC was 54.39±12.83 years. The ages of the patients were increasing from grade 1 to grade 4 ($p<0.001$). As the SIFK Degree increased, the FTA angle increased ($p=0.002$).The FTA was higher in grade 3-4 SIFK patients. As the grade increased, MM extrusion increased ($p<0.001$) (**Table 4**).

Table 3.Distribution of variables by classifcation of SIFK

Variables	Classifcation of SIFK				p
	Grade 1 n (%)	Grade2 n (%)	Grade3 n (%)	Grade4 n (%)	
Gender					0.337
Female	76 (58.5)	55 (57.9)	49 (70)	7 (53.8)	
Male	54 (41.5)	40 (42.1)	21 (30)	6 (46.2)	
Lateralization					0.553
Left	68 (52.3)	53 (55.8)	42 (60)	9 (69.2)	
Right	62 (47.7)	42 (44.2)	28 (40)	4 (30.8)	
LKOA					0.001
None	32 (24.6)	11 (11.6)	18 (25.7)	2 (15.4)	
Grade 1	63 (48.5)	52 (54.7)	18 (25.7)	2 (15.4)	
Grade 2	20 (15.4)	16 (16.8)	21 (30)	6 (46.2)	
Grade 3	6 (4.6)	11 (11.6)	8 (11.4)	3 (23.1)	
Grade 4	9 (6.9)	5 (5.3)	5 (7.1)	0 (0)	
MKOA					<0.001
None	28 (21.5)	9 (9.5)	10 (14.3)	0 (0)	
Grade 1	45 (34.6)	22 (23.2)	16 (22.9)	0 (0)	
Grade 2	28 (21.5)	36 (37.9)	14 (20)	3 (23.1)	
Grade 3	15 (11.5)	15 (15.8)	20 (28.6)	9 (69.2)	
Grade 4	14 (10.8)	13 (13.7)	10 (14.3)	1 (7.7)	
SIFK Location on coronalplane					0.025
(P)1	50 (38.5)	23 (24.2)	13 (18.6)	2 (15.4)	
(C)2	73 (56.2)	62 (65.3)	50 (71.4)	11 (84.6)	
(I)3	7 (5.4)	10 (10.5)	7 (10)	0 (0)	
SIFK Location on sagital plan					0.054
(A)1	10 (7.7)	10 (10.5)	6 (8.6)	3 (23.1)	
(C)2	81 (62.3)	40 (42.1)	37 (52.9)	5 (38.5)	
(P)3	39 (30)	45 (47.4)	27 (38.6)	5 (38.5)	
Location of menisca ltear compartment of knee					<0.001
None	54 (41.5)	16 (16.8)	6 (8.6)	0 (0)	
Medial	47 (36.2)	37 (38.9)	30 (42.9)	9 (69.2)	
Lateral	4 (3.1)	3 (3.2)	2 (2.9)	0 (0)	
Both	25 (19.2)	39 (41.1)	32 (45.7)	4 (30.8)	
Medial meniscus tear type					<0.001
None	59 (45.4)	20 (21.1)	8 (11.4)	0 (0)	
Root	22 (16.9)	28 (29.5)	17 (24.3)	10 (76.9)	
Radial	6 (4.6)	7 (7.4)	14 (20)	0 (0)	
Other	43 (33.1)	40 (42.1)	31 (44.3)	3 (23.1)	
Lateral meniscus tear type					0.011
None	101 (77.7)	53 (55.8)	36 (51.4)	8 (61.5)	
Root	1 (0.8)	1 (1.1)	1 (1.4)	0 (0)	
Vertical	0 (0)	0 (0)	1 (1.4)	0 (0)	
Other	28 (21.5)	41 (43.2)	32 (45.7)	5 (38.5)	
Medial meniscus extrusion grade					<0.001
None	73 (56.2)	45 (47.4)	23 (32.9)	3 (23.1)	
Mild	19 (14.6)	17 (17.9)	14 (20)	0 (0)	
Moderate	26 (20)	14 (14.7)	17 (24.3)	1 (7.7)	
Severe	12 (9.2)	19 (20)	16 (22.9)	9 (69.2)	
Lateral meniscus extrusion grade					<0.001
None	111 (85.4)	67 (70.5)	43 (61.4)	7 (53.8)	
Mild	6 (4.6)	4 (4.2)	9 (12.9)	3 (23.1)	
Moderate	8 (6.2)	7 (7.4)	15 (21.4)	1 (7.7)	
Severe	5 (3.8)	17 (17.9)	3 (4.3)	2 (15.4)	

Pearson chi-square test was used.

Table 4.Distribution of age, weight, BMI, femorotibialangle, meniscusextrusionaccordingtothe SIFK system.

Variables	Classifcation of SIFK				p
	Grade 1 Mean±SS	Grade 2 Mean±SS	Grade 3 Mean±SS	Grade 4 Mean±SS	
Age	54.39±12.83 (a)	58.02±11.85 (b)	61.75±10.33 (c)	61.5±5.01 (abc)	<0.001
Weight	73.77±6.73	72.38±7.16	72.76±7.66	74.23±5.8	0.446
Height	1.67±0.04	1.66±0.04	1.67±0.04	1.67±0.03	0.195
BMI	26.54±2.3	26.13±2.43	26.21±2.79	26.59±2.28	0.782
Femorotibial angle	4.42±2.57 (a)	5.09±2.26 (b)	5.74±2.78 (b)	5.95±2.54 (b)	0.002
Medial meniscus extrusion	1.73±2.37 (a)	2.29±2.79 (ab)	2.73±2.43 (b)	5.09±3.29 (c)	<0.001
Lateral meniscus extrusion	0.64±1.73 (a)	1.63±2.81 (b)	1.33±1.95 (b)	1.63±2.29 (ab)	0.006

One way ANOVA was used. (abc): In same row, Common letter sindicate statistical in significance.

Age 52 years and older with 88.7% sensitivity and 33% specificity (AUC 0.621; p <0.001), a FTA of 3.1 degrees or more, with 89.1% sensitivity and 31.5% specificity (AUC 0.605; p=0.003), MM extrusion greater than 2.5 mm can predict high-grade SIFK lesion, with a sensitivity of 59.04% and a specificity of 65.33% (AUC 0.633; p <0.001) (**Figure 6**).

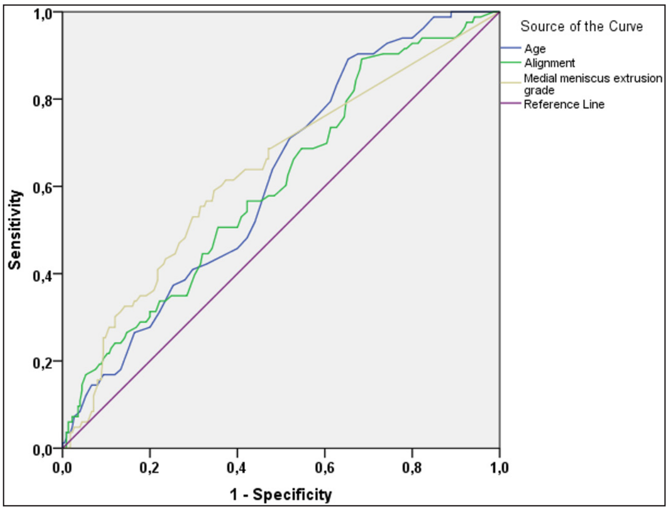

Figure 6: Age, meniscus extrusion and femorotibial angle ROC analysis graph showing its relationship with SIFK lesion

DISCUSSION

Current study showed in ROC analysis that three important risk factors,increasedMM extrusion, older age and increased FTA, contribute to the development of SIFK. FTA was affected by meniscus tear type and exturation. In particular, ≥52 years of age, with acute knee pain with FTA ≥3.1°, we recommend to perform MRI if possible. Our study found that the degree of OA in a joint was directly related to the severity of SIFK.

In the healthy population, the distal femur and proximal tibia orientation are usually parallel (20). Increased FTA causes excessive shear stress on the articular cartilage by increasing joint line obliquity. According to the study of Nakayama's et al. (21) shear stress in the medial compartment is increased by 1.5 times if the joint line is inclined five degrees from normal, and doubled if the joint line is inclined by 10°. Cooke et al. (22) found that the progression of OA was affected by increasing varus in the distal femur and/or proximal tibia. Tsukamoto et al. (23) suggested that two important risk factors, such as varus deformity in the proximal tibia and knee joint laxity, contribute to the development of the early phase of SONK. There are studies in the literature with opposite findings. For example Yamagami et al. (20) did nor find any significant difference for the mean tibial varus angle between SONK and OA.

Previous studies have revealed that tears of the posterior root of the MM are highly associated with SIFK and hypothesized that biomechanical changes secondary to loss of ring strength result in increased contact pressures and axial loading on weight-bearing surfaces (24). In our study, radial and root tear in the MM rate was 28% in patients with low grade while 57.9% in patients with high grade.

Several reports have shown an association between knee OA and SIFK (1,6,25). In our study, only 15,3% of the patients had no signs of OA in the medial compartment, while this rate was 20.5% in the lateral compartment. In our study group, the high number of patients with OA is not clearly known as it is a cross-sectional study and there is no follow-up, as it is a cross-sectional study and whether SIFK triggers OA or whether OA causes SIFK. Since the meniscus has the role of protecting the knee joint surface from mechanical stress, it is known that meniscus injury is also associated with the development of knee OA (26).

Most of these meniscal abnormalities are medial meniscal tears, often on the same side of the SIFK (25,27). The most common tear is the posterior root tear, followed by a radial tear in the posterior horn (27). If this ring mechanism is disrupted due to meniscal tears, extrusion or resections, the contact pressure on the knee's loading surface increases, which can lead to the development of SIFK (26). There are some reports showing a relationship between SIFK and medial meniscal tear or showing a relationship between SIFK and meniscectomy (7). Most of these meniscal abnormalities are medial meniscal tears, often on the same side of the SIFK (25). The most common tear is the posterior root tear, followed by a radial tear in the posterior (5). Tears in the posterior root of the meniscus are considered a risk factor for meniscus extrusion (24), medial meniscal tear was higher with a rate of 39.9% in our study, but the rate of medial meniscus root and radial tear was relatively low in our study (13.9%). Medial meniscal tear has been suggested as a potential etiology of SONK (24). Disruption of collagen fibers in the meniscus causes meniscus extrusion, which causes a change in the load distribution in the knee (28). Loss of significant load distribution function with meniscal extrusion may simulate a situation similar to meniscectomy (7,29). Arthroscopic meniscectomy results in osteonecrosis of the knee in some patients (30). Greater meniscus extrusion results in greater opening and articular surface contact and greater force in the subchondral area. Our study shows that both medial and lateral meniscus extrusion is greater in cases with severe high grade SIFK. The rate of patients without MM extrusion was 52.4% in low-grade SIFK patients, while it was 31.3% in high-grade SIFK patients. However, not all SIFK occurs in the setting of a meniscal tear, and not all meniscal tears progress to SIFK. As a matter of fact, 24.7% of the patients in our study did not have any meniscal tear.

Plett et al. (25) reported that 64.4% (47/73) of 73 SIFK patients were women. In our study, this rate was 60.7%. It was previously described that SIFK is more common in female patients aged 60 years and over (31). In our study, the rate of women was high. In addition, the mean age of women was higher than that of men. In the literature, it has been reported that advanced lesions are more common in women (32). In our study, high grade SIFK was more common in women with 67.5%.

SIFK is most commonly seen in the weight-bearing region of the medial femoral condyle (MFC)(33). Wilmot et al analyzed 74 cases of SIFK and found that 64.9% (48/74) of the cases were in the medial femoral condyle, 16.2% (12/74) were in the lateral femoral and 2.7% (2/74) were at medial tibial condyles. The striking finding here was that the lesion was in the middle 1/3 of the condyle, which carries the load (70-77%) (32). In our study, in the sagittal plane the SIFK was in the coronal plane with a rate of 63.6% and 52.9% were in the central.

Studies on the relationship between patient weight and SIFK have shown that overweight patients have more stress on the lower extremity joints. Zanetti et al. found that 40.6% (13/32) of SIFK patients were overweight or obese (body mass index >25.0 kg/m²) (34). However, it was recently reported that body weight was not associated with the prognosis of SIFK (12). In our study, no difference was found in terms of weight, height and BMI.

This study has several limitations. First, this study is a retrospective and cross-sectional analysis. It is not clear whether SIFK causes OA or, on the contrary, OA causes SIFK, since there is no clinical follow-up of the patients. There is no tracking of the FTA angle. We were unable to determine whether the increased FTA was the cause or the result. Prospective long-term studies are needed to clarify this point. We compared OA classification patients with MRI only. Standing knee X-rays and ortho-radiography were not available.

CONCLUSION

As a result, radiographic parameters of SIFK were compared. Significantly larger FTA deformity was observed in SIFK. Clinicians should suspect the onset of SIFK in patients with acute knee pain with an FTA greater than 3.1°.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Tokat Gaziosmanpaşa University Hospital Ethics Committee (Date: 2022, Decision No: 22-KAEK-019).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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