Original Article / *Özgün Araştırma*

DOI: 10.4274/haseki.galenos.2018.4375
Med Bull Haseki 2019;57:32-36

Assessment of the Relationship Between the Femorotibial Angle and Meniscal Injury with Radiologic Imaging Methods

Femorotibial Açı ile Meniskal Yaralanmalar Arasındaki İlişkinin Radyolojik Görüntüleme Yöntemleri İle Birlikte Değerlendirilmesi

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Abstract

Aim: Our aim in this study was to determine the relationship between femorotibial angle and meniscal injuries and to evaluate the relationship between femorotibial angle and development of osteoarthritis.

Methods: One hundred and one patients aged >18 years who had undergone knee magnetic resonance imaging and anterior-posterior radiographs were retrospectively re-evaluated. All magnetic resonance imaging scans of the knee was evaluated for meniscal injury, and femorotibial angle measurements were performed from the knee anterior-posterior radiographs. The relationship between femorotibial angle values and presence of meniscal injury was analyzed statistically.

Results: In total, 101 knee joints belonging to 101 patients (55 female, 46 male) were included in the study. The median femorotibial angle value was 4°C (1-12) in the knee joints with medial meniscal injury and 4°C (0-12) in the normal knee joints. This was not statistically significant (p>0.01). The median femorotibial angle value was 5°C (1-12) in the knee joints with lateral meniscal injury and 4°C (0-12) in the normal knee joints. This was not statistically significant (p>0.01).

Conclusion: In our study, there was no statistically significant relationship between femorotibial angle values and presence of injury in medial and lateral menisci.

Keywords: Femorotibial angle, meniscal injury, radiographs, magnetic resonance imaging

Öz

Amaç: Çalışmamızın amacı femorotibial açı ile menisküs yaralanmaları arasındaki ilişkiyi saptamak ve femorotibial açı ile osteoartrit gelişimi arasındaki ilişkiyi değerlendirmektir.

Yöntemler: Kliniğimizde diz manyetik rezonans görüntüleme ve diz ön arka radyografileri bulunan 18 yaşının üzerinde 101 hasta retrospektif olarak değerlendirildi. Menisküs yaralanmaları için diz manyetik rezonans görüntüleri değerlendirildi. Femorotibial açı ölçümleri ise diz ön arka radyografilerden yapıldı. Femorotibial açı değerleri ile menisküs yaralanması arasındaki ilişki istatistiksel olarak analiz edildi.

Bulgular: Çalışmamıza 101 hastaya ait 101 diz eklemi dahil edildi. Yüz bir hastanın 55'i kadın olup 46'sı erkekti. Medial menisküs yaralanması bulunan diz ekleminde median femorotibial açı değeri 4°C (1-12) olup normal diz ekleminde 4°C (0-12) idi. İki grup arasında istatistiksel olarak anlamlı ilişiki saptanmadı (p>0,01). Lateral menisküs yaralanması olan diz ekleminde median femorotibial açı değeri 5°C (1-12) olup normal diz ekleminde 4°C (0-12) idi. İki grup arasında istatistiksel olarak anlamlı ilişiki saptanmadı (p>0,01).

Sonuç: Çalışmamızda femorotibial açı değerleri ile medial ve lateral menisküslerde yaralanma arasında istatistiksel olarak anlamlı bir ilişki saptanmadı.

Anahtar Sözcükler: Femorotibial açı, menisküs yaralanması, radyografi, manyetik rezonans görüntüleme

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Received/Geliş Tarihi: 26 April 2018 **Accepted/Kabul Tarihi:** 18 June 2018

Introduction

The meniscus provides an important role in maintaining joint congruity and stability. The primary biomechanical function of the meniscus is distributing the axial load. Other functions are absorbing shock, and providing lubrication and nutrition to the knee joint (1). Load distribution problems in the knee joint can be seen in meniscal injuries (2). Degenerative arthritis may occur when the stress increases on the articular cartilage (1). The load is unproportionally transmitted to the medial compartment of the knee during walking (3). Malalignment is an important biomechanical factor in the progression of knee osteoarthritis (OA) (4). The intersection of the femoral and the tibial axes forms the femorotibial angle (FTA) which is normally 5°C-7°C (5). Loading on the medial and lateral menisci and compartments changes when the angle changes (6).

Our aim in this study was to determine the relationship between FTA and meniscal injuries and to evaluate the relationship between FTA and the development of OA.

Methods

Patients

Review board approval was obtained to review the records of patients who had undergone anterior-posterior (AP) radiography of the knee joint and knee magnetic resonance imaging (MRI) between November 2017 and January 2018. One hundred and one patients (46 male, 55 female) aged >18 years who had undergone knee MRI and AP radiography at our department were retrospectively re-evaluated from the picture archiving and communication system. Patients who had acute trauma, ligamentous knee joint injury, previous knee surgery, and benign or malignant mass lesion were not included in the study.

Written informed consent was obtained from the patients who participated in this study.

Institutional Review Board approval (meeting number: 2018/1, date: 09.01.2018, protocol number: 7) was obtained from Samsun Education and Research Hospital.

Radiologic Protocol and Imaging

The MRI images were obtained with a 1.5 Tesla MAGNETOM Aera® MRI device (Siemens Healthcare, Erlangen, Germany) with a knee coil. Scan sequences included a sagittal T1-weighted turbo spin-echo (TR/TE: 500/17), a sagittal proton density spectral attenuated inversion recovery (PD SPAIR) (TR/TE: 3000/30), an axial PD SPAIR (TR/TE: 3353/30), a coronal T2-weighted SPAIR (TR/TE: 2500/50), sagittal T2-weighted SPAIR (TR/TE: 2619/62), and an axial T2-weighted SPAIR (TR/TE: 3353/30)—slice thickness, 3.5 mm and gap, 0.3 mm.

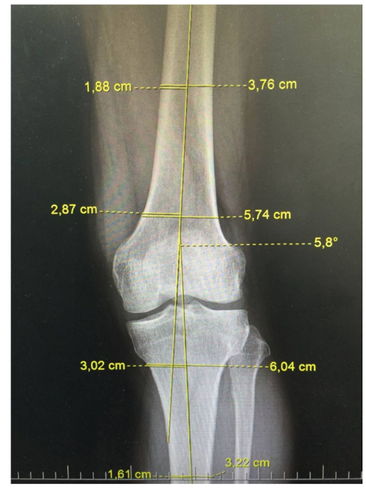

Figure 1. Measurement of the femorotibial angle using AP knee radiography

AP: Anotomy and physiology

All knee MRIs were evaluated for meniscal injury, and FTA measurements were performed from the knee AP radiographs. Evaluation of OA was performed on the knee MRI and the knee radiographs. In addition, the anterior cruciate ligaments (ACL) were evaluated on the knee MRIs.

The anatomic FTA was calculated using the anatomical axes of the femur and the tibia on the AP knee radiographs. The FTAs were measured by drawing a line along the axis of the femoral shaft to intersect the corresponding line drawn through the tibial shaft (Figure 1). The FTAs were noted in these patients. In addition, a meniscal evaluation was performed through an MRI for each patient. Meniscal injuries were evaluated in at least two consecutive images. The assessment of the meniscal injuries is presented in Table 1 (7). In our study, grade 1 and grade 2 meniscal injuries were considered degeneration; grade 3 was considered a meniscal tear (Figure 2a-c).

The imaging findings of OA are given in Table 2 (8). The findings of OA were evaluated using the knee radiographs and the MRIs.

We used 2D fast spin echo (FSE) sequences with fat suppression to evaluate the ACL. Axial and coronal images were used for evaluating ACL injuries.

Statistical Analysis

An IBM statistical software package (IBM SPSS Statistics version 20 for Windows; IBM SPSS Inc., Armonk, NY, USA) was used to perform all statistical calculations. The Mann-Whitney U test was used in the two-group comparisons, and the Kruskal-Wallis H test was used in the comparisons of more than two groups because the variables were not normally distributed.

The mean, standard deviation (SD), and proportion were used as descriptive statistics. A p value of less than

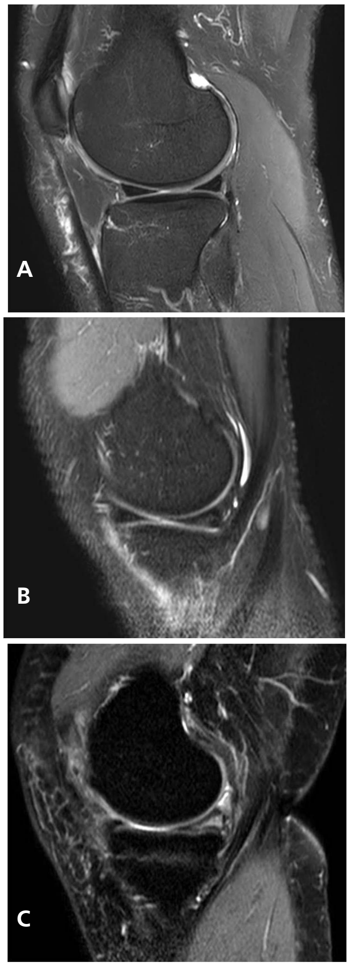

Figure 2. (a) Sagittal T2-weighted spectral attenuated inversion recovery (SPAIR) MR image (TR/TE: 2619/62) shows a hyperintense focal area at the posterior horn. There is no extension to the articular surface (grade 1 degeneration). (b) Sagittal proton density (PD) SPAIR MR image (TR/TE: 3000/30) demonstrates linear areas of hyperintensity at the posterior horn. There is no extension to the articular surface (grade 2 degeneration). (c) Sagittal PD SPAIR MR image (TR/TE: 3000/30) shows abnormal hyperintensity extends to the articular surface at the posterior horn [grade 3 (tear)]

MR: Magnetic Resonance

Table 1. Magnetic resonance imaging grading system for abnormal high meniscal signal intensity

Grade 1	Small focal area of hyperintensity, no extension to the articular surface
Grade 2	Linear areas of hyperintensity, no extension to the articular surface
Grade 3 (tear)	Abnormal hyperintensity extends to at least one articular surface (superior or inferior), and is referred as a definite meniscal tear

Table 2. The imaging findings of osteoarthritis

Radiography	Joint space narrowing
	Subchondral sclerosis
	Marginal osteophytes
	Subchondral cysts (geodes)
	Altered shape of the femoral condyles and tibial plateau
MRI	Synovial thickening
	Bone marrow oedema
	Cartilaginous defects (partial or complete)

MRI: Magnetic resonance imaging

0.05 was considered significant in all statistical analyses. All data are expressed as mean ± SD and median (maximum-minimum).

Results

Patients

In total, 101 knee joints (52 right, 49 left) belonging to 101 patients with the mean age 46.67±13.4 were included in the study. A total of 55 of the 101 patients were female (mean age: 49±10.8 years), and 46 were male (mean age: 43.89±15.5 years) (Table 3).

Radiologic Protocol and Imaging

There were medial meniscal injuries in 64 knees. Of these, 31 were meniscal tears, 33 were grade 1 and 2 degeneration. The medial meniscus (MM) was normal in 37 knees (Table 4). There were lateral meniscal injuries in 26 knees. Of these, 9 were meniscal tears, 17 were grade 1 and 2 degeneration. The lateral meniscus (LM) was normal in 75 knees (Table 4).

The mean FTA value in the knees was 4.93±3°C for all patients. The mean FTA value in females and males was 4.91±3.1°C and 4.96±2.9°C, respectively. The median FTA values of the MM and LM are shown in Table 5. There was no statistically significant relationship between the FTA values and the presence of injury (degeneration or tear) in the medial and lateral menisci (Table 5).

Table 3. Distribution of patients by gender

		Female	Male	Total
Medial meniscus	Degeneration	21	12	33
	Tear	16	15	31
	Normal	18	19	37
Lateral meniscus	Degeneration	13	4	17
	Tear	5	4	9
	Normal	37	38	75
Anterior cruciate ligament	Sprain	7	7	17
	Rupture	5	10	15
	Normal	43	29	72

Table 4. Distribution of the meniscus injuries according to right and left knee

		Right	Left	Total
Medial meniscus	Degeneration	18	15	33
	Tear	11	20	31
	Normal	23	14	37
Lateral meniscus	Degeneration	6	11	17
	Tear	4	5	9
	Normal	42	33	75

Table 5. Femorotibial angles in knees with and without injury						
Minimum		FTA				
		Maximum	Median	Range	p	
Medial meniscus	Degeneration	1	11	5	10	
	Normal	0	12	4	12	>0.01
	Tear	1	12	4	11	
Lateral meniscus	Degeneration	1	12	4	11	
	Normal	0	12	4	12	>0.01
	Tear	1	12	5	11	
Anterior cruciate ligament	Sprain	0	7	4	7	
	Normal	1	12	4	11	>0.01
	Rupture	1	12	3	11	

FTA: Femorotibial angle

Forty-one of 101 patients (15 male, 26 female) had imaging findings of OA in the knee joint (20 R, 21 L). The knee joints (32 R, 28 L) were normal in 60 patients (31 male, 29 female). The median FTA value in patients with the imaging findings of OA in the knee joint was 4°C (1-12). The median FTA value in patients with normal knee joints was 4°C (1-12). There was no statistically significant difference in FTA value between these two groups (p>0.01).

Fourteen of the 101 patients had sprains in the ACL, and 15 had complete tears. This was detected by MRI. The ACL was normal in 72 patients. The median FTA value in patients with an ACL sprain was 4°C (0-7); it was 3°C (1-12) in those with ACL rupture. The median FTA was 4°C (1-12) in patients with normal ACL (Table 3). There was no statistically significant relationship between the FTA values and the presence of injury (sprain or rupture) in the ACL (Table 5).

Discussion

Menisci are important structures of the knee joint. They increase stability for femorotibial articulation, distribute the axial load, absorb shock, and provide lubrication and nutrition to the knee joint. The meniscus is responsible for supporting 40-70% of the load in the knee. The remaining load is distributed by direct contact with the articular cartilage (2). Menisci are wedge-shaped, semilunar, fibrocartilaginous structures. There are two menisci in the knee: the MM and the LM (1). MRI is the most accurate and least invasive method for diagnosing meniscal lesions. In addition, soft tissues, articular cartilage, tendon injuries, and ligaments can be evaluated better with an MRI than with other imaging methods (1,3). A normal meniscus is seen as a triangular-shaped low intensity signal on T1- and T2-weighted sequences or on FSE sequences (1).

Meniscal injuries increase with age and are often associated with and contribute to degenerative joint disease (1). The MM is less mobile than the LM and is more susceptible to injury. Because the posterior horn of the MM absorbs most of the weight of the medial compartment, a posterior horn MM tear is common. Lateral meniscal tears are more common in the younger population and frequently occur secondary to acute trauma (1,3). The criteria of the meniscal tears diagnosing with MRI include either an increased intrasubstance signal unequivocally contacting the articular surface or meniscal distortion in the absence of prior surgery. The positive predictive value for a tear is 94% in the MM and 96% in the LM, if these findings are seen on two or more images. Also, imaging findings should be accepted as a meniscal tear (1). These imaging findings must be detected in the same area on any two consecutive MR images. These consecutive images can be two coronal images, two sagittal images, or one coronal and one sagittal image

In their study evaluating 114 knee joints of 101 patients, Sirik (3) reported that the mean FTA value was 5.6±1.88 in the knee joints with a MM injury and 5.8±1.92°C in the normal knee joints. This was not statistically significant (p=0.82). In our study, the median FTA value was 4°C (1-12) in the knee joints with a medial meniscal injury and 4°C (0-12) in the normal knee joints. This was not statistically significant (p>0.01). Sirik (3) reported that the mean FTA value was 6.1±1.50°C in the knee joints with a LM injury and 5.6±1.96°C in the normal knee joints. This was not statistically significant (p=0.20). In our study, the median FTA value was 5°C (1-12) in the knee joints with a lateral meniscal injury and 4°C (0-12) in the normal knee joints. This was not statistically significant (p>0.01).

OA is referred to as degenerative arthritis or degenerative joint disease. OA is characterized by the progressive deterioration of the articular cartilage or of the entire joint, including the articular cartilage, the synovium (joint lining), the ligaments, and the subchondral bone (bone beneath the cartilage) (4). Radiological imaging methods for the evaluation of OA include AP and lateral radiographs, CT and MRI. Knee radiography is still the most commonly used imaging technique for evaluating a patient with a known or suspected diagnosis of OA. In addition, the radiograph is cheaper than the other imaging methods, and it is very accessible (5,6). Changes in the FTA value disrupt knee alignment. Malalignment of the knee is an important risk factor for the development of knee OA (5, 6). In our study, the median FTA value was 4°C (1-12) in the knee with OA and 4°C (0-12) in the normal knee joint. This was not statistically significant (p>0.01).

The ACL is the most important structure that provides the normal biomechanics of the knee. One of the most common knee injuries is a sprain or tear (9). The normal ACL should have a taut, low-to intermediate-signal intensity with continuous fibers in all planes and sequences. It courses parallel to or steeper than the intercondylar line. The primary sign of an ACL tear is discontinuity in the fibers. The accuracy, sensitivity, and specificity of MRI in ACL ruptures are more than 90%. Oblique sagittal plane with coronal and axial images is very useful in diagnosis. The empty notch sign on coronal imaging is a frequent finding in a complete ACL tear (9). A sprain involves the overstretching of the ligaments, which are the fibrous connective tissues that connect the bones to one another and stabilize them. In our study, the median FTA value was 3°C (1-12) in knees with ACL tear and 4°C (1-12) in normal ACL. This was not statistically significant (p>0.01).

Conclusion

In our study, there was no statistically significant relationship between the FTA values and the presence of injury (degeneration or tear) in medial and lateral menisci. In addition, there was no statistically significant relationship between the FTA values and the development of OA. We considered that there was no relationship between malalignment of the knee and changes in FTA value.

Authorship Contributions

Concept: E.S., A.T.S. Design: E.S., A.T.S. Data Collection or Processing: E.S., A.T.S. Analysis or Interpretation: E.S. Literature Search: A.T.S. Writing: E.S.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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