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Medial Meniscus Extrusion is Correlated with Varus Alignment in Patients Without Meniscus Tear

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ABSTRACT

Introduction: There is a well-established connection between medial meniscus lesions and varus leg alignment, and medial meniscus lesions like posterior root tears are known to cause meniscus extrusion. However, the evidence regarding the relation between varus alignment and meniscus extrusion in knees without meniscus lesions is controversial. Our study aimed to evaluate the correlation between varus alignment and meniscus extrusion in knees without meniscus lesions.

Methods: One hundred thirty knees of 113 patients, with a mean age of 48.8±11.3 years, 33.8% male, without meniscus lesions and with long leg radiographs and knee magnetic resonance imaging, were retrospectively analyzed. Extrusion was considered positive if it exceeded 3 mm. Varus malalignment of legs was grouped as mild (0°-4.9°), moderate (5°-9.9°), and severe (≥10°) according to hip-knee-ankle (HKA) angle measurement, and it was also noted that bone edema in the medial compartment was present. The correlation among extrusion measurement, varus malalignment HKA, and bone marrow edema was analyzed.

Results: Fifty-seven knees (43.8%) had extruded menisci. The mean HKA angle was 4.6±3.6. 82 legs (63.1%) had mild, 37 legs (28.5%) had moderate, and 11 legs (8.5%) had severe varus. Bone marrow edema was noted in 88 knees (66.7%). Relationship between extrusion and severity of varus ($p<0.001$) and bone marrow edema ($p<0.001$) was significant. The extent of meniscal extrusion showed significant correlation with HKA angles (coefficient =0.481, $p<0.001$).

Conclusion: Varus malalignment was revealed to correlate with medial meniscus extrusion in knees without meniscal damage.

Keywords: Meniscus, varus, extrusion, knee, alignment

Introduction

Menisci are fibrocartilaginous, wedge-shaped, and load-absorbing structures composed of type I collagen, elastin, proteoglycans, glycoproteins, and water. In addition to the balanced transmission of the load in the knee, it has functions such as stability, proprioception, and smoothness of motion (1).

The arrangement of the fibres in the normal meniscus structure enables the conversion of compressive loads into circular loads (i.e. hoop stress). It also eliminates the mismatch between the proximal tibia and the distal femur. This prevents degeneration of the articular cartilage. The relationship between disruption of normal meniscal structure and degenerative changes in articular cartilage (2), subchondral lesions, bone marrow edema (3), and alignment changes such as narrowing of the joint space (4) has been demonstrated.

Menisci can extrude from the tibial plateau within physiologic limits in the absence of degeneration, joint pathologies, and malalignment (5). Other than this, extrusion can be present in conditions that disrupt the meniscal structure, such as meniscal tears or degeneration (6). More than a 3 mm extension (1,7) is considered an extruded meniscus. Extruded meniscus is an independent risk factor for articular cartilage degeneration (8).

Varus deformity is a predisposing factor for articular cartilage degeneration, meniscal damage and osteoarthritis (9). The pathogenesis of this condition is due to the mechanical axis of the leg lying more medially and the load on the medial aspect of the knee increasing beyond physiologic limits (10). Meniscal extrusion may be expected in varus deformity due to disruption of the joint load distribution. However, there is no consensus on the relation between extrusion and varus alignment, besides meniscal lesions such as meniscal root tears or degeneration (11-13).

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The aim of this study was to assess the relationship between meniscal extrusion and varus alignment in patients with varus deformity without medial meniscal tear or degeneration. We hypothesised that varus malalignment would lead to meniscal extrusion.

Methods

In this study, 459 adult patients (ages 18-65) with knee magnetic resonance (MR) imaging and long leg radiographs (LLR) who applied to the orthopaedics and traumatology outpatient clinics of our hospital between March and June 2023 were retrospectively analyzed. Exclusion criteria were as follows: patients with meniscal tear on MR imaging, patients with symptoms and/or examination findings that may be related to meniscus in clinical examinations (snapping sensation in the knee joint, positive McMurray sign, pain with deep pressure to medial joint space), patients with valgus alignment on LLR, patients with a history of ipsilateral surgery, and patients without optimal imaging. Finally, 130 knees (67 right, 63 left) of 113 patients (44 males, 69 females, mean age 48.8±11.3) were enrolled (Table 1). The study flowchart is shown in Figure 1.

The LLR were taken with the patient standing, knees in full extension, 100 cm from the beam source, the detector parallel to the ground, and the centre of the radiograph directed at the patellofemoral joint (14). We determined the optimal radiographs as those where the patella was facing forward and both hip and ankle joints were seen. Measurements were performed using the hospital picture archiving and communication system [Innbiotec (DICOM) Viewer, Innbiotec Software, Dubai, UAE]. Hip-knee-ankle (HKA) angle measurement (Figure 2) was used to evaluate leg alignment. According to the HKA angle, patients were divided into three groups: mild (0°-4.9°), moderate (5°-9.9°), and severe (≥10°) varus (15).

MR imaging of the knee was obtained in knee extension as a standard procedure. The distance from the end of the medial tibial plateau to the border of the medial meniscus was measured in the midcoronal plane on coronal T2 MR slices (Figure 3). A distance of more than 3 mm was classified as extruded meniscus (7). The presence of bone marrow oedema in the medial compartment was also noted. All radiographic measurements were performed twice at three-week intervals by two observers blinded to the diagnosis.

Ethical Approval

This study was performed in accordance with the Helsinki Declaration. Consent was gathered from each of the participants enrolled in our study. The study was approved by the University of Health Sciences Türkiye, Ankara Etlik City Hospital Clinical Research Ethics Committee (approval number: AEŞH-EK1-2023-531, date: 22.11.2023).

Statistical Analysis

Statistical evaluation of the data was performed using statistical package for the social sciences (Windows) 20.0. Conformity to the normal distribution was examined by the Kolmogorov-Smirnov test. The chi-square test was used to analyze categorical data. Correlation analyses were performed using the Pearson correlation test. Inter- and intra-observer reliability of measurements was evaluated using intraclass correlation coefficient (ICC) and the results of reliability analyses were presented as mean ICC. Post-hoc power analysis was performed using G*power version 3.1.9.6 (Franz Paul, Kiel, Germany). Data were analyzed at a 95% confidence level and tests were considered significant if the p-value was less than 0.05.

Results

The mean ICC of the observations was 0.92 for HKA angles and 0.93 for meniscus extrusion measurements, and the mean Cohen's kappa coefficient was 0.95 for bone bruise. The mean HKA angle of 130 legs was 4.6±3.6. Eighty-two legs (63.1%) had mild, 37 legs (28.5%) had moderate, and 11 legs (8.5%) had severe varus. The mean meniscus extrusion measure in knee MR imaging was 2.9±1.9 mm. With the predefined cut-off of 3 mm, 57 knees (43.8%) did and 73 knees (56.2%) did not have extruded menisci.

Correlation analysis revealed a significant positive relationship between HKA angles and meniscus extrusion (coefficient =0.481, $p<0.001$). Also, when categorical data were analyzed, a significant difference was observed between varus severity groups in terms of the presence of meniscus extrusion ($p<0.001$).

Bone marrow oedema in the medial compartment was present in 88 knees (66.7%). There was a significant relationship between the presence of meniscus extrusion and bone marrow oedema ($p<0.001$). Data and results of statistical analyses are presented in Table 2. Post-hoc power analysis was performed with a significance level (alpha) set to 0.05 and revealed a power of 99.97% for the study.

Discussion

Although it has been previously shown in the literature that varus deformity is a risk factor for meniscal lesions (16) and meniscal lesions cause meniscal extrusion (6), our study revealed that varus deformity has a direct and significant relationship with meniscal extrusion without meniscal tear.

The meniscus bears 40-70% of the load on the knee and is responsible for the balanced distribution of "hoop stress" through the placement of collagen fibres in the meniscal structure (7). Disruption in this collagen

Table 1. Symptoms of patients

Symptoms of patients	n (%)
Anterior knee pain	67 (51.6%)
Swelling/effusion	30 (23.1%)
Lateral knee pain	25 (19.2%)
Palplable mass	3 (2.3%)
No active symptoms (i.e. follow-up of a soft tissue lesion)	3 (2.3%)
Patellar instability	2 (1.5%)

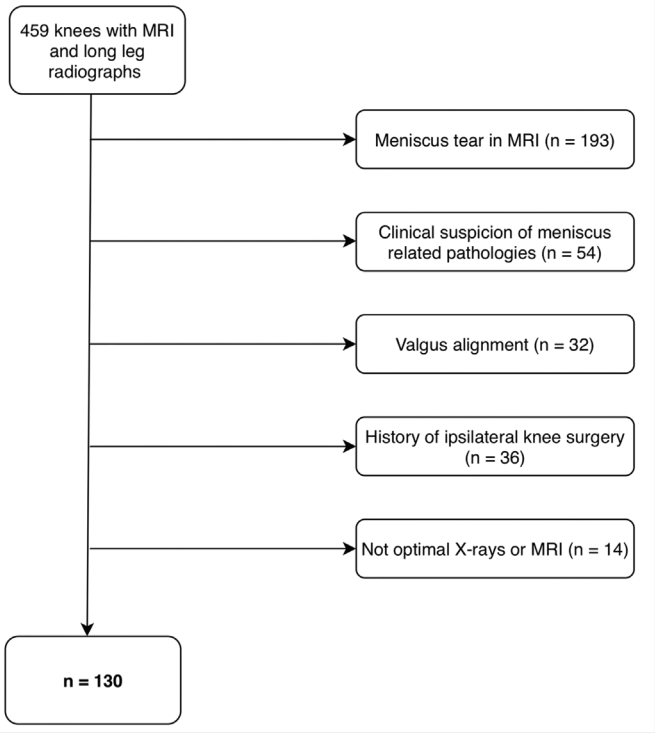

Figure 1. Study flowchart
MRI: Magnetic resonance imaging

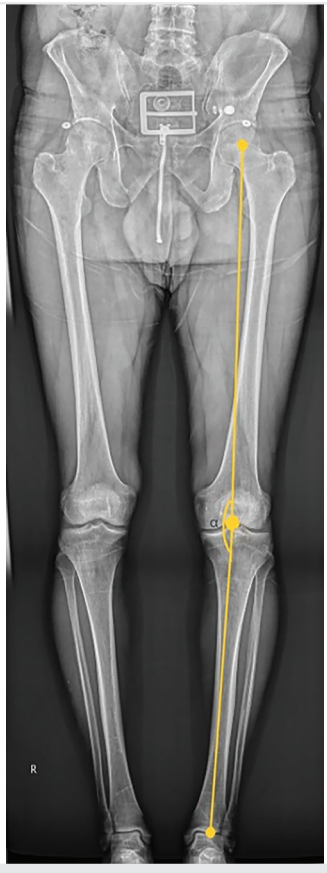

Figure 2. Hip-knee-ankle angle was measured in long leg radiographs as the angle between mechanical axes of femur and tibia (180-alpha)
R: Right

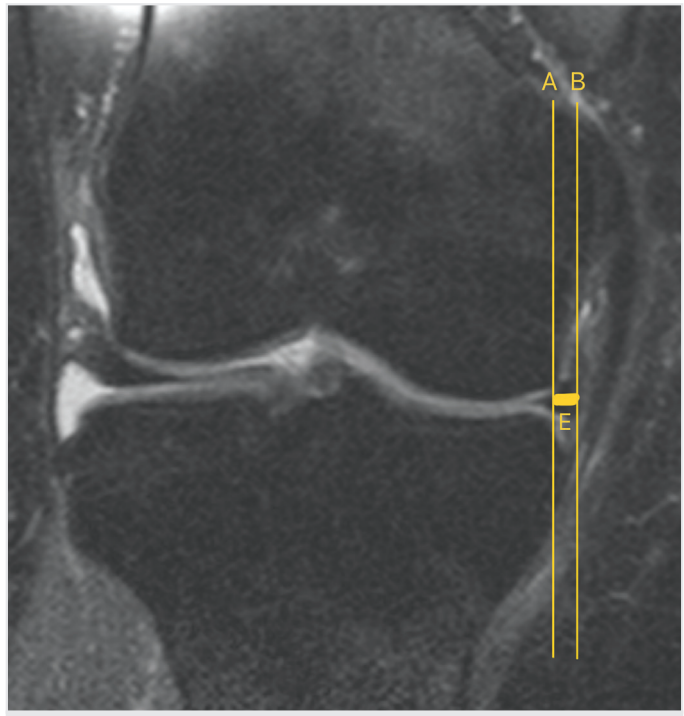

Figure 3. Meniscal extrusion (E) was measured in midcoronal MRI slice as the distance between the most medial points of medial plateu (A) and medial meniscus (B)
MRI: Magnetic resonance imaging

structure impairs the load balance and may lead to joint degeneration. The relationship between meniscal lesions and joint degeneration has been previously reported in the existing literature (2,17). The medial meniscus is more frequently affected due to its location, the amount of load it carries, and the fact that it has a tighter connection with the structures in the medial part of the joint than the lateral part (18) through structures such as the meniscotibial and meniscofemoral ligaments. It plays a greater role in joint degeneration when damaged (7).

Meniscal extrusion can be defined as the displacement of the circumferential fibres from the meniscotibial compartment, as a result of their inability to bear the load (18). When meniscal extrusion was first described, it was suggested that it did not cause a pathology on its own, and was a consequence of other pathologies (19). Recent studies have demonstrated a positive relationship between meniscal extrusion and cartilage loss (20), osteophytes (8), subchondral cysts, and bone marrow oedema (21). Biomechanically, meniscal extrusion and load on the medial compartment are correlated (22).

Nevertheless, it has been reported (1,5) that some amount of meniscal extrusion, not exceeding the threshold value, may occur in knees without signs of degeneration and may not always be associated with osteoarthritis (1,5), although the cause has not been fully elucidated. Meniscotibial and meniscofemoral ligament lesions may lead to meniscal extrusion in the absence of tears (1). It has also been suggested that lesions of these ligaments are a predisposing factor for root tears (23). Current literature suggests that severe meniscal extrusion is a pathologic condition by itself and proposes various treatment options (24,25). Furthermore, as it has been shown that meniscal extrusion can progress even after the repair of a meniscal root tear (26), it remains uncertain

Table 2. Demographic data and results of analyses

	Extrusion <3 mm (n=73)	Extrusion ≥3 mm (n=57)	p value
Age (years)	44.2±11.1	54.6±8.6	<0.001 (1)
Sex			0.554 (2)
Male	28 (38.4%)	19 (33.3%)	
Female	45 (61.6%)	38 (66.7%)	
HKA angle	3.15±2.4°	6.64±3.97°	<0.001 (1)
Severity of varus			<0.001 (2)
Mild	59 (80.8%)	23 (40.4%)	
Moderate	14 (19.2%)	23 (40.4%)	
Severe	0 (0%)	11 (19.2%)	
Bone marrow edema present	9 (12.3%)	33 (57.9%)	<0.001 (2)

HKA: Hip-knee-ankle angle

whether additional predisposing factors such as malalignment may play a role in this condition.

It has been shown that medial meniscal extrusion can cause medial osteoarthritis accompanied by varus deformity (18). In addition, Crema et al (11). examined cases with and without osteoarthritis and concluded that varus alignment had an independent association with meniscal extrusion, but it was not clear which meniscal lesion was associated with the development of osteoarthritis. However, it should be added that in this study, patients with meniscal tears, including meniscal root tears, were also included in the varus deformity group. In addition, Erquicia et al (13). found no relationship between meniscal extrusion and limb alignment. In our study, unlike a previous study, we found a direct correlation between varus deformity and meniscal extrusion ($p<0.001$).

Problems affecting the medial compartment of the knee joint cause bone marrow oedema, especially in the medial condyle (3,27). The relationship between bone marrow oedema, which can be spontaneous, mechanical, or reactive (27), and meniscal extrusion has been previously demonstrated (3). In our study, we found that meniscal extrusion and bone marrow oedema were more frequently observed together in patients without meniscal tears or degeneration ($p<0.001$). This may be interpreted as an indication, that the mechanical load on the medial compartment of the knee joint increases due to extrusion. While this relationship has been demonstrated by biomechanical studies for varus malalignment (16), biomechanical studies on the increased mechanical load as a direct result of meniscal extrusion are insufficient.

Study Limitations

Other than its retrospective design, the limitations of our study include that the symptoms and/or clinical findings of the patients were not correlated with radiographic findings. However, if this examination had been performed, it could have led us to obtain data unrelated to the purpose of the study. In addition, the use of data from a variety of MR imaging devices in the measurements can be considered another limitation. The large number of observations and high interobserver agreement may partially overcome the possible effects of this disadvantage. Evaluating meniscal extrusion with MR images taken without axial loading may affect the results. However, it is currently believed that the gold standard evaluation method for meniscal extrusion is MR imaging, and weight-bearing imaging such as ultrasonography may not provide adequate quality and quantitative measurements (28).

Conclusion

Our study found that varus alignment, which is one of the controversial risk factors for meniscal extrusion, may be directly associated with meniscal extrusion in patients without meniscal tears. There is also a positive correlation between extrusion of medial meniscus and bone oedema in the medial compartment of the knee joint.

Ethics

Ethical Approval: The study was approved by the University of Health Sciences Türkiye, Ankara Etlik City Hospital Clinical Research Ethics Committee (approval number: AEŞH-EK1-2023-531, date: 22.11.2023).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions: Surgical and Medical Practices - F.B.; Concept - F.B., A.Ç., H.A.A.; Design - M.K., M.S.Ç.; Data Collection or Processing - F.B., E.B.D., H.A.A.; Analysis or Interpretation - C.G., M.A., Y.A.; Literature Search - E.B.D.; Writing - F.B., A.Ç., E.B.D.

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

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