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Femoral Trochlea Morphology: A Gender and Bilateral Comparative Study Using MRI

Femoral Troklear Morfoloji: MRG ile Cinsiyet ve Bilateral Karşılaştırmalı Çalışma

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Öz

Amaç : Literatürde troklear morfolojiyi ölçmede sulkus açısı ve troklear derinlik yaygın olarak kullanılmaktadır. Bu çalışmada amacımız magnetik rezonans görüntüleme (MRG) kullanılarak femoral trokleada cinsiyet temelli anatomik farklılıkları saptamaktır.

Gereç ve Yöntemler: Çalışmaya toplamda 100 hasta (50 kadın, 50 erkek) dahil edildi. Tüm hastalarda her iki dizde aksiyal MR görüntülerinde femoral sulkus açısı ve troklear derinlik kullanılarak troklear morfoloji analiz edildi.

Bulgular: Ortalama troklear derinlik erkeklerde 9.1 ± 1.5 mm , kadınlarda ise 6.9 ± 1.4 mm ve ortalama femoral sulkus açısı erkeklerde 127 ± 9.3 ° ve kadınlarda 134.7 ± 8.6 ° idi. MRG de sağ ve sol diz arasında istatistiksel olarak anlamlı fark saptanmadı.

Sonuç: Bu çalışma troklear morfolojide cinsiyetler arasında fark olduğunu tanımladı. Troklear groove kadınlarda erkeklerden daha sığ ve geniştir.

Anahtar Kelimeler: troklea, sulkus açısı, manyetik rezonans görüntüleme,

Abstract

Objective: The sulcus angle and trochlear depth have been widely used in the literature as a measure of trochlear morphology. The purpose of our study was to assess gender-based anatomical differences of the femoral trochlea using magnetic resonance imaging (MRI).

Materials and Methods: A total of 100 patients (50 women, 50 men) were included in our study. All patients had both their knees analyzed; trochlear morphology was measured using trochlear depth, and the femoral sulcus angle on axial MR images.

Results: The mean trochlear depths in the men and women were 9.1 ± 1.5 mm and 6.9 ± 1.4 mm, and the mean femoral sulcus angles in the men and women were 127 ± 9.3° and 134.7 ± 8.6°, respectively. Using MRI, no statistically significant differences were found between the right and left knees.

Conclusion: This study demonstrates significant gender differences in trochlear morphology. The trochlear groove is significantly less deep and shallower amongst women than in men.

Key words: trochlea, sulcus angle, magnetic resonance imaging,

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Introduction

The trochlea is a bony structure located on the femur's distal end, and part of the patellofemoral articulation that also encompasses the anterior section of the intercondylar fossa (1-5). The sulcus of the trochlear groove is located lateral to the midplane between the femoral condyles, and is oriented between the anatomic and mechanical axes of the femur (3, 4). Normal trochlear bony anatomy contributes to patellofemoral joint stability. Acquired or congenital changes in the surface geometry of the patellofemoral joint can lead to various clinical disorders, such as chondromalacia patella, instability in the patella, and knee pain (5, 6).

Numerous studies in the literature have used the sulcus angle to evaluate the morphology of the trochlea. The femoral sulcus angle is thought to represent the depth of the trochlear groove (3, 4). Recently, trochlear depth has been reported as alternative (7-10). Anatomic variations between the knees of men and women have been reported in many studies. There is little detailed information in the literature concerning gender-specific differences in the trochlear groove of the knee. Using magnetic resonance imaging (MRI), this investigation analyzes measurements of the trochlear region, and evaluates gender and right-left differences.

Materials and Methods

Patients: The patients who had undergone bilateral knee MRI analyses for any indication between January and December 2016 were evaluated retrospectively. Patients who had undergone any knee surgery, those with a history of acute trauma, those with trochlear dysplasia (6) were excluded. Thus, a total of 100 patients were involved in the study. Body mass index (BMI) was calculated by dividing weight in kg by the square of the height in meters (kg/m^2). The study was approved by the hospital's Institutional Review Board (1076-2016).

MRI: The MR images (Optima, GE Medical System, Milwaukee, Wisconsin, USA) of the patients were taken with a 1.5 T unit using an extremity coil. A standardized MRI examination protocol was used and the axial, sagittal, and coronal (proton-density, T1 and T2-weighted) MR images were implemented for each patient.

For all trochlear measurements, the cartilage was excluded and only the osseous surfaces were used as a reference. Axial fat-suppressed proton-density fast spin echo sequences (TR:2742 ms, TE: 39.8 ms, thickness: 3 mm, matrix: 228x224, FOV: 18x18 cm) were used to analyze the axial images, respectively.

Image Interpretation: The patients' MRIs were retrospectively evaluated using our Picture Archiving and Communication System (PACS) by the same radiologist. We evaluated the morphological features of the trochlea using trochlear sulcus angle and trochlear depth. These measurements were taken from the axial (fat-suppressed proton-density fast spin echo) MR images in which the largest posterior femoral condyle was observed (i.e.,the slice above and below demonstrated a small posterior femoral condyle) (Fig 1a,b).

The trochlear depth was defined as the maximum distance of the trochlear groove from the line connecting the medial and lateral trochlear facets. The osseous angle formed between the medial and lateral facets were simultaneously measured and determined to be the trochlear sulcus angle.

In order to assess the reliability of the measurements, the same radiologist performed the measurements twice with an interval of three weeks, in 50 knees randomly selected from the 200 knees in this study.

Statistics: The statistical analyses were evaluated using the SPSS 15.0 (SPSS Inc., Chicago IL) program. The distribution between the groups was normal with the Kolmogorov–Smirnov test. The test data were shown to be homogeneously distributed by Levene's test, and parametric tests were used for intergroup comparisons. The trochlear morphologic easures

were compared between the women and men subjects by independent t test. Those parameters were compared between the right and left knees using an independent t test. $p<0.05$ was considered statistically significant.

A post-hoc power analysis was performed using the G Power 3.1 software. To estimate the power analysis, the sample size of each group and the alpha and effect size d values were used. Alpha error probability, effect size d value, and the statistical power of the study (1-eta) were 0.05, 0.8, and 0.9, respectively. The intra-class correlation coefficient (ICC) was used to estimate the intra-observer reliability for trochlear region measurements.

Results

The characteristics of the 100 subjects are shown in Table 1. The distributions of trochlear region measurements by gender are given in Table 2. In our study, the trochlear depth found to be less in women than in the men, and the femoral sulcus angle was higher in women than in the men ($p<0.05$).

Both in women and men, no significant differences were found between the trochlear morphologic measurements when left and right knees were compared ($p> 0.05$). The ICC for intra-observer reliability for trochlear sulcus angle and trochlear depth were 0,88 and 0,90, respectively.

Table 1. Characteristics of the study population.

Characteristic	Women	Men	Total
Age (year)	45 ± 12	42.9 ± 11.7	43.9 ± 11.8
BMI(kg/m²)	27.7 ± 5.9	27.3 ± 3.2	27.5 ± 4.7

(Values are expressed as mean ±standard deviation) (BMI: Body mass index)

Table 2. Gender comparative results of the trochlear measurement.

	Women	Men	p-value
Trochlear depth	6.9 ± 1.3	9.1 ± 1.5	0.01
Femoral sulcus angle	*134.6* ± 8.7	126.6 ± 9	0.01

(Values are expressed as mean ± standard deviation)

Discussion

This study demonstrates significant gender differences in trochlear morphologic measurements. In our study, we found no significant difference between the right and left knees in either gender. Patellofemoral osteoarthritis is a common orthopedic problem. Structural damage to the patellar cartilage may develop as a result of patellofemoral morphological variations or anatomical incompatibility. Therefore, the evaluation of the morphological properties of the patellofemoral joint plays an important role in the diagnosis of patellofemoral osteoarthritis (11).

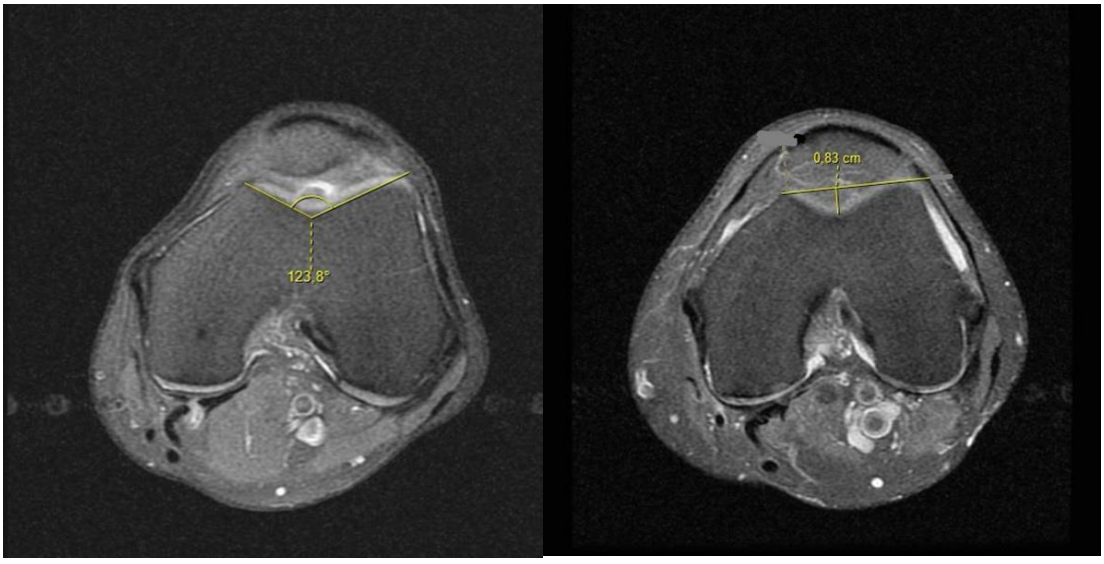

Figure 1 (a-b): MR images shows axial measurements in a 42-year-old man who underwent knee MRI, a. Femoral sulcus angle, b. Trochlear depth

A number of researchers have examined the morphology of the trochlea by assessing both the depth and angle of the trochlear sulcus (7-10). In the axial radiograph of the patellofemoral joint, Merchant (12) reported that the normal sulcus angle has been defined as 138°. Alemparte et al (13) showed that the sulcus angles were obtained from computerized tomography (CT) scan images with mean values of 139.7 ± 20.4°. On the other hand, we determined the sulcus angle as 130 ± 9.7° in our study with MRI.

In their MRI study, Murshed et al (4) determined the mean femoral sulcus angle in males and in females as 134 ± 5.1° and 133.2 ± 6.7°, respectively. Alemparte et al (13) found gender differences in the femoral sulcus angle but Murshed et al (4) did not. In this study, a significant gender difference was found in the femoral sulcus angle. In our study, the women had femoral sulcus angles of 134.6 ± 8.7°, while the men's were 126.6 ± 9°. Our results are in agreement with that of Alemparte et al (13) that reported women as having a higher sulcus angle.

Endo et al (8) reported that trochlear groove depth was 9.2 ± 1.5 mm in patients with chondromalasia patella. In one study, patients presenting with symptomatic patellar instability had a reported depth of 2.3 ± 1.8 mm compared with a depth of 7.8 ± 1.5 mm in an symptomatic control group (14) .We determined the trochlear depth as 8 ± 1.4 mm in our study and our results are in agreement with previous studies. Haster et al (15) reported that trochlear cartilaginous depth differed significantly by gender with a mean value of 3.4 mm for women and a mean value of 4.2 mm for men. In their study, the first axial cut from proximal with complete cartilage coverage was used for measurements. The measurements of osseous and cartilage structures in the trochlear groove are different (16, 17). We decided to use the axial MR images in which the largest posterior femoral condyle for our standardised measurement. In our study, the women had trochlear depth of 6.9 ± 1.3 mm, while the men’s were 9.1 ± 1.5 mm and we found a significant difference for the osseous trochlear depth by gender.

In the present study, there was no significant difference in the morphologic measurements of the trochlea when the measurements of both the right and left knees were compared. Our findings were in agreement with the previous studies (4, 14).

Patellofemoral osteoarthritis is more prevalent in women than in men (18). Shallow femoral trochlea can lead to patellar instability with subsequent disproportionl load distribution across the patellofemoral joint during knee movements. High mechanical stress on either side of patellofemoral joint may cause degenerative changes in the articular cartilage (19, 20). A shallow femoral trochlea is a risk factor for osteoarthritis of patellofemoral joint, particularly in women.

The femoral sulcus angle and trochlear depth can be seen on axial radiographs, in CT, and in MRI of the patellofemoral joint (4, 6). MRI is reported to be more effective than conventional radiography in determining and characterizing the overall architecture of the trochlear sulcus, since radiography measurements can only visualize the lower areas of the trochlear sulcus and therefore are not able to provide a complete picture of the whole trochlear shape. As a consequence, MRI is considered to be the most reliable method currently available for evaluating the depth of the trochlear groove (3, 21).

However, our study has some limitations. The study design is retrospective and based on morphological characteristic in symptomatic patients using MRI. Therefore, there was also no standardized positioning of the relevant knees in MRI, inducing slight differences with regard to the grade of knee extension.

In conclusion, the results of our study are significant in that they provide important information concerning the effect of gender on trochlear morphology. Our study determined that the trochlear groove is significantly less deep and shallower amongst women than in men.

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Conflict of interest: The authors declare that there is no conflict of interest.

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