

Knee Version Associated With Anterior Knee Pain

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Version of the knee in the presence and absence of anterior knee pain was evaluated by computed tomography in this study. Version of the knee is defined as the static rotation of the tibia with respect to the femur in full knee extension. Fourteen patients in whom conservative management for anterior knee pain failed were compared with 14 volunteers with no symptoms. Computed tomography images of the femoral condyles and tibial plateau were obtained with the knee extended. The angle between the bicondylar and posterior tibial axes was measured. This angle, representing external rotation of the tibia relative to the femur, was increased significantly in patients with symptoms (7°) compared with volunteers with no symptoms (1°). This increased knee version identifies a unique morphologic characteristic of the knee with anterior pain.

Anterior knee pain is associated with a long list of patellofemoral disorders of which the primary biomechanical cause is malalignment of the knee extensor mechanism.¹⁶ This

malalignment is attributed to angulation in the coronal plane (genu valgum, lateral displacement of the tibial tubercle) or rotation in the transverse plane (femoral anteversion, tibial torsion). Traditional studies of anterior knee pain focus on the coronal relationships (Q angle, patellar tilt, patellar subluxation) and infrequently address the rotational relationships, specifically the rotational orientation of the tibia to the femur. To the best of the authors' knowledge, this rotational relationship of the tibia to the femur in the transverse plane referred to as knee version⁵ has not been reported in the knee with anterior pain. This feature may play a significant role in patellar tracking and the development of anterior knee pain. The patella is a passive component of the extensor mechanism where the static and dynamic relationships of the underlying tibia and femur determine the patellar tracking pattern. This study was undertaken to investigate the rotational alignment of the knee with anterior pain and compare the rotation of the tibia with the version in symptomatic versus asymptomatic knees.

MATERIALS AND METHODS

Fourteen patients in whom conservative management for anterior knee pain failed (nonsteroidal anti-inflammatory drugs, physical therapy, patellar brace) were compared with 14 volunteers with no symptoms. The patient group consisted of 13 women and

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years. The control group consisted of 13 women and one man, 20 to 52 years of age, with an average age of 35 years. Neither the patients nor the volunteers had any history of knee surgery or trauma. Neither the patients nor the volunteers had any signs or radiographic changes of osteoarthritis (narrowing of cartilage, bone spurs, cysts, increased sclerosis).

A computed tomography (CT) scan of the femoral condyles, immediately proximal to the notch, and the tibial plateau, immediately proximal to the tubercle, was obtained in each knee in full extension. The extended knee was selected because this is the only position in which the tibia assumes a reproducible position in rotation relative to the femur.¹³ Additional CT cuts were obtained through the femoral head, femoral shaft at the lesser trochanter, and across the malleoli to determine limb rotation after the method of Mesgarzadeh et al.¹⁸

The static rotation of the tibia with respect to the femur in extension (version of the knee) was measured as the angle between the line determined by the two most posterior points of the femoral condyles and the line determined by the two most posterior points of the tibial plateau on the respective CT cuts (Fig 1). Other parameters recorded included the femoral anteversion,¹⁸ tibial version,¹⁸ Q angle,¹ sulcus angle,² congruence angle,¹⁷ and patellar tilt.¹⁵

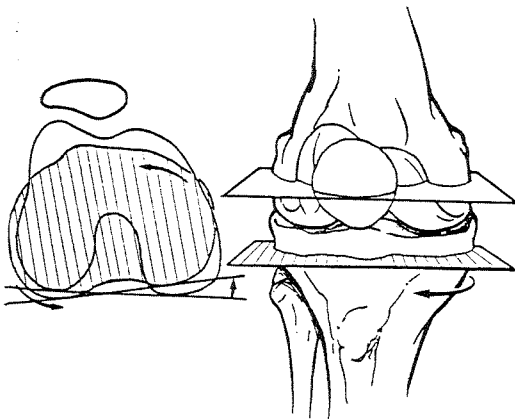


Fig 1. Version of the knee is determined by measuring the angle between the line joining the posterior tibial condyles and the line joining the posterior femoral condyles on the CT scan of the knee in full extension.

Comparison was made between the right and left extremity of each individual in both groups using a paired t test, and comparison also was made between the two groups using an unpaired t test. Correlations were attempted between the measured parameters in each subject using a regression analysis.

RESULTS

A significant difference ($p < 0.05$) was found in the angle between the femoral condyles and the tibial condyles in patients versus controls. Patients with patellofemoral pain had mean angles of 8.1° on the right and 6.3° on the left, compared with 1.3° on the right and 0.4° on the left in controls. No significant differences were found in any other parameters. No correlation could be made between parameters (Table 1).

DISCUSSION

This study was undertaken to investigate one entity, rotation of the tibia relative to the femur in the presence of anterior knee pain, that was not identified in a review of the extensive literature devoted to the topic of anterior knee pain. Traditional discussions of anterior knee pain focus on patellar position and orientation to characterize the pathology. For example, Q angle, sulcus angle, congruence angle, and patellar tilt are the traditional parameters typically measured in patients with anterior knee pain. With the development of axial radiographic techniques^{8,11,14,16,21} and the subsequent introduction⁴ and popularization^{9,20} of CT scanning, these parameters have become the principle descriptors of the knee with anterior pain.

Overall limb alignment associated with anterior knee pain, specifically rotational limb alignment, is addressed infrequently in the literature devoted to anterior knee pain. Increased femoral anteversion and tibial torsion have been identified as features of the knee with anterior pain,^{3,6,10,19} but rotation of the tibia to the femur across the knee, referred

TABLE 1. Results Showing a Significant Increase in Knee Version in Patient Group

Descriptors of Patella Malalignment	Control Group (mean \pm standard error)	Patient Group (mean \pm standard error)
Femoral anteversion ($^{\circ}$)	18.8 \pm 1.9	22.2 \pm 2.1
Knee version ($^{\circ}$)	1.0 \pm 0.4*	7.2 \pm 1.1*
Tibial version ($^{\circ}$)	37.0 \pm 1.7	32.8 \pm 1.7
Sulcus angle ($^{\circ}$)	123.5 \pm 2.3	133.6 \pm 4.9
Congruence angle ($^{\circ}$)	8.6 \pm 1.1	15.1 \pm 2.8
Patella tilt ($^{\circ}$)	20.7 \pm 1.4	18.5 \pm 1.7
Q angle ($^{\circ}$)	28.1 \pm 1.7	39.9 \pm 1.9

*Statistical difference at $p < 0.05$.

to as knee version,⁵ has not been recognized as a characteristic of the knee with anterior pain. To the best of the authors' knowledge, knee version has been documented only in the context of the osteoarthritic knee.^{5,22,23} The data presented in this study show that there is an external rotation of the tibia with respect to the femur in the knee with anterior pain that is greater than that of the asymptomatic knee.

The significance of this rotational characteristic of the knee with anterior pain is that the patella is tethered to the tibia by the infrapatellar tendon and retinaculum, and if the tibia is rotated externally with respect to the femur, the patella will be pulled laterally by virtue of this attachment. Applying simple trigonometry, 5 $^{\circ}$ external rotation measured across the back of the tibia (Fig 1) will translate the tubercle 5 to 10 mm laterally in the average knee, increasing the Q angle approximately 5 $^{\circ}$ to 10 $^{\circ}$. If the patella is not free to translate laterally because of its soft tissue attachments and its conformity with the femoral trochlea, there may be increased pressure on the lateral facet. This appears to be the condition first described by Ficat et al⁷ as the lateral patellar compression syndrome. The data presented in this study suggest that this syndrome, characterized as anterior knee pain in the absence of patellar tilt or subluxation, may be associated with increased rota-

tion of the tibia relative to the femur. This rotation of the tibia relative to the femur becomes a risk factor for the development of anterior knee pain.

Although version of the knee has not been described previously, the associated lateralization of the tibial tubercle alluded to has been documented. In a patient population similar to that described in this study, lateralization of the tubercle was measured by CT scan to be 12.2 \pm 0.5 mm in patients with anterior knee pain and 6.5 \pm 0.4 mm in asymptomatic control subjects.¹² This 6-mm lateralization of the tubercle is the displacement that one can predict, as demonstrated, from a model in which the axis of the posterior femoral condyles and the posterior tibia condyles diverge by 5 $^{\circ}$ more than normal. The previously documented lateralization of the tibial tubercle can be interpreted as confirming the presence of knee version described here, assuming that tubercle lateralization is viewed as a product of three-dimensional rotation and not simply two-dimensional translation of an isolated muscular attachment.

The clinical relevance of these observations may be found in the traditional management of anterior knee pain. An adjunct to the usual therapy regimen (short arc quadriceps strengthening exercises) may be strengthening of the internal tibial rotators (semimembranosus, gracilis, semitendinosus, sartorius).

Greater emphasis may be given to hamstring stretching, particularly the biceps femoris, while adding stretching of the iliotibial band. However, the impact of these adjunctive therapies is difficult to predict because data in this study are limited to static knee extension, a position in which there is relatively little influence from muscle contraction on tibial rotation.¹³ Kinematic studies of the knee with anterior pain are needed to define the relative position of the tibia to the femur in flexion and to define the variation that occurs with motion.

Traditional discussions of the knee with anterior pain focus on the coronal position of the patella. However, the patella is a passive component in the extensor mechanism whose position is determined by the rotational orientation of the tibia to the femur. The increased external rotation of the tibia in relation to the femur reported in this study in symptomatic knees may account, in part, for the anterior knee pain in patients and identify a risk factor for individuals who have anterior knee pain.

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