Patellar Instability - What a Radiologist Should Know!

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Learning objectives

• To briefly describe the normal anatomy of patellofemoral joint.
• To identify the relevant risk factors for patellar instability and describe the methods and measurements to evaluate them.
• To review the pathology and imaging findings of patellar instability.
Background

Introduction

Patellar problems are the most frequent type of knee complaint in adolescents and young adults. Patellar pathology manifests itself in different clinical entities ranging from isolated anterior knee pain to dislocation.

Patellar instability is the morphologic abnormality in patellofemoral joint, which leads to recurrent patellar dislocations. Most patients are young and active individuals, especially females in the 2nd decade.

Patellar dislocation is characterized by the complete loss of contact between the patellofemoral joint surfaces. The prevalence of acute patellar dislocation is 6-77 per 100,000 population. If the patient experiences a subsequent patellar dislocation, there is a 50% chance of recurrent episodes. Although the recurrence rate is relatively low after a primary patellar dislocation, many patients continue to have pain and mechanical symptoms after the initial dislocation episode.

Chronic patellar instability, if not treated, may lead to severe arthritis and chondromalacia patellae.

Normal Anatomy

The patellofemoral joint is the articulation of the patella (sesamoid bone encased in the extensor mechanism) and the trochlea of the femur (the anterior surface of the femoral condyles of the distal femur). This joint is a complex structure with normal function dependent on the relationship between the patella and the trochlear groove. The patella has nine facets, but basically can be divided into larger medial and lateral facets, that are separated by a median ridge. The lateral facet is longer and more sloped to match the lateral femoral condyle and is normally 1 cm higher than the medial, what helps to maintain the patella in a centered position in the trochlea. When the knee is fully extended, the patellar cartilage is mostly superior to the trochlear cartilage. As the knee flexes to 30°, the patella begins to engage with the trochlea, and between 30 and 90° of flexion the patellar cartilage articulates with the trochlear cartilage. As the patella moves distally with knee flexion, the contact area on the patella moves proximally. In deep knee flexion (120°), the medial facet, contacts the lateral margin of the medial femoral condyle and the inner border of the medial femoral condyle is in contact with the small vertical ridge of the medial facet.

Patellofemoral Stabilizers
The articulation and path of motion of the patella is complex, with the joint vulnerable to several levels, or types, of instability.

In general, three groups are responsible for stability: active stabilizers (quadriceps mechanism), passive stabilizers (retinacula), and static stabilizers (articular surfaces). Patellofemoral instability may result when the normal relationships are disturbed.

**Active Stabilizers**

The most important component of quadriceps muscle for patellofemoral tracking and stability is the vastus medialis obliquus (VMO).

Loss of VMO tension causes significantly reduced lateral patellar stability.

**Passive Stabilizers**

The tissues overlying the medial aspect of the knee have been divided into three primary layers of patellar support described by Warren et al. Layer 1 is the most superficial and defined by the fascia of the sartorius muscle. Layer 2 is the intermediate layer and is defined by the medial patellofemoral ligament (MPFL). The MPFL is a continuation of the deep retinacular surface of the VMO muscle fibers and runs transversely from the proximal half of the medial patellar border to the femur near the medial epicondyle. Layer 3 is the innermost layer, and corresponds to the joint capsule.

Passive stabilizers are present as uniform restraints of abnormal joint motion. In the patellofemoral joint, these structures include the patellar ligament or patellar retinacular complexes, which include the patellofemoral and patellotibial ligaments.

The patellofemoral retinaculum and ligaments provide their greatest contribution to patellofemoral stability between full extension and 30° of knee flexion. It is at this point in the arc of motion that patellofemoral stability relies on soft tissue restraints. The MPFL is believed to be the primary passive restraint to lateral patellar displacement. It provides 50% to 60% of lateral restraint from 0° to 30° of knee flexion.

**Static Stabilizers**

Patellofemoral joint stability is influenced by the geometry of the trochlear groove, including its depth and steepness.

The lateral condyle forms the lateral wall of the patellofemoral articulation and is the most important restraint to lateral patellar translation once the patella is engaged.
A more widely recognized aspect of osseous alignment is the quadriceps angle, or Q angle. Alterations in the Q angle can result from deviations from normal lower extremity skeletal anatomy, that play an important role in patellofemoral tracking and patellofemoral forces. It describes the direction of pull of the quadriceps mechanism relative to that of the patellar tendon. The measurement is obtained by the intersection of a line drawn from the anterosuperior iliac spine to the center of the patella, with a second line drawn from the center of the tibial tuberosity to the center of the patella. For males the mean Q angle is approximately 10° and for females it is approximately 15°, plus or minus 5°. Because the Q angle is greatest in full extension, this is the position in which the patella is at greatest risk for dislocation. As the Q angle increases, both the exerting lateral displacement force and patellar contact pressure increase. In addition, the tendency for lateral tilt also increases. The factors that can increase this Q angle are genu valgum, increased femoral anteversion, external tibial torsion, or a laterally positioned tibial tuberosity. The Q angle also can be increased in a dynamic mode by internally rotating the femur on a fixed tibia. Any of these factors that increase the Q angle can be a contributing element in recurrent patellar instability. The Q angle is, however, difficult to measure and can sometimes be underestimated, because of the mobility of the patella. Quadriceps tension pulls the patella in a proximal and lateral direction in full extension. If the patella is unstable, it subluxates laterally, resulting in a falsely low Q-angle measurement. Limb rotation can also change this measurement since external tibial torsion can increase the apparent Q angle.

**Patellofemoral Instability**

Patellofemoral instability is a common cause of knee pain and disability.

Patellofemoral instability generally is defined as acute or chronic. Acute instability refers to a primary, traumatic episode in which the patella dislocates laterally, while chronic instability denotes recurrent dislocations. The most common mechanism of first-time patellar dislocation is a knee with internal rotation in a flexed position, on a planted foot with a valgus component.

Both static and dynamic forces tend to displace the patella laterally, and in almost all cases, the patella dislocates laterally. Medial dislocations are rare and are typically iatrogenic.

Lateral tracking of the patella leads to decreased efficiency of the quadriceps extensor mechanism and increased patellofemoral joint stress. A lateral patellar subluxation of only a few millimeters results in decreased contact surface area between the patellar and trochlear surfaces. Lateral tracking pushes the lateral facet closer to the lateral side of the trochlear groove, thus, creating a greater distance between the medial facet and the medial side of the trochlear groove. The total stress over the patellofemoral joint, distributed over both patellar facets, is now completely transmitted through the lateral patellar facet, increasing lateral facet stress.
Patellofemoral alignment describes the static relationship of the patella and trochlea at a given degree of flexion; tracking refers to the dynamic relationship during knee motion. Abnormalities of alignment and tracking may be due to imbalance of forces from a combination of variables involving passive, active, and static stabilizers.
Findings and procedure details

Radiological techniques are frequently used to assist clinical decision-making and differential diagnosis. Radiological assessments used include conventional radiographs, computed tomography (CT) and magnetic resonance imaging (MRI).

The radiographic series for the examination of the patellofemoral joint includes an anteroposterior (AP), lateral, and Merchant view. The AP roentgenogram is of limited use regarding patellofemoral problems. This view may reveal a bipartite patella, which is a variant of normal anatomy. Occasionally, an osteochondral fracture of the medial patellar edge, loose bodies or osteochondral fractures can be seen.

Fig. 1: Patellar dislocation evident on the left, on an anteroposterior view.

References: Department of Radiology, Hospital de São João/ Porto 2013

The lateral view yields more commonly used information relating to patella alta. The most widely used axial view is the Merchant view (or skyline view) and this view is used to assess for patellar tilt, patellar subluxation, and trochlear dysplasia.
Fig. 2: Assessment of patella alta (technique of Insall-Salvati) on lateral radiographs.

References: Department of Radiology, Hospital de São João/ Porto 2013

It is important to note that a significant amount of information can be gained from these studies, but they are limited.

Cross-sectional imaging with transverse CT slices at different positions along the lower limb can provide a three-dimensional view of the patellofemoral joint and can be used to assess the lateral offset of the tibial tuberosity from the deepest point in the trochlear groove. Also, with the knee extended, the lateral tilt of the patella can be more pronounced in patients who have patellar subluxation than in normal control groups. The patients with patellar subluxation have a lesser degree of abnormality, and the subluxation is not seen with the knee flexed 30° to 45°, as is usual in most routine axial views.

Studies similar to those made with CT scans can easily be accomplished with MRI without exposure to radiation, although they involve considerable expense. An MRI may be indicated in the acute setting if osteochondral injuries are suspected, as they are associated with a poor outcome if not addressed. MRI can also be helpful in determining the site of retinacular or patellofemoral ligamentous injury if the physical examination is equivocal and surgical repair is contemplated. Kinematic MRI may be useful in the chronic setting and provides the most physiologic means of evaluating the patellofemoral joint, because dynamic images are obtained, allowing the interpretation of muscular contributions for patellar instability.

A recent study by Smith et al concluded that there is a reasonable level of inter-observer and intra-observer reliability and validity for measurements of patellar height, the sulcus angle as assessed with radiographs, MRI and CT and the TT-TG assessed with CT. There is insufficient evidence to determine the reliability, validity, sensitivity or specificity
of tests such as the congruence angle, lateral patellar displacement, lateral patellar tilt, trochlear depth or crossing sign.

**Risk Factors for Instability**

Instability of the patellofemoral joint is a multifactorial problem. Patellar stability relies on the limb alignment, the osseous architecture of the patella and the trochlea, the integrity of the soft-tissue constraints, and the interplay of the surrounding muscles.

Many authors have questioned whether a "normal" patellofemoral joint can dislocate, but most believe that there is an anatomic predisposition.

The most common predisposing factors to patellofemoral instability include dysplasia of the patella or trochlear groove, patella alta and lateralization of the tibial tuberosity.

Additional factors that may contribute to patellofemoral instability include a change in orientation of the fibers of the vastus medialis muscle, atrophy of the vastus medialis, hypertrophy of the vastus lateralis, femorotibial malrotation, genu recurvatum, and generalized ligamentous laxity (Ehlers-Danlos and Marfan syndromes).

Quadriceps dysplasia is usually confirmed in permanent patellar dislocation, but, like Dejour et al stated, its a notion that is difficult to qualify and quantify. However, external patellar tilt can be a measurable expression of quadriceps muscle dysplasia, and can identify minor forms of quadriceps dysplasia, using the mean angle with and without quadriceps contraction. In summary, quadriceps dysplasia is characterized by two factors: the patellar tilt in extension and patella alta.

**Trochlear Dysplasia**

Abnormal morphology of the femoral trochlea is referred to as trochlear dysplasia, with a flattened joint surface proximally and less pronounced concavity distally.

This alteration is believed to be a development abnormality because of its high frequency of bilateralism. Signs of trochlear dysplasia are found in more than 85% of patients with patellar dislocation.

**Trochlear Morphology**

Abnormal trochlear morphology has been classified in four types by Dejour et al:

Type A - normal shape of trochlea, but shallow trochlear groove.
Type B - markedly flattened or even convex trochlea.

Type C - trochlear facet asymmetry, with too high lateral facet, and hipoplastic medial facet.

Type D - type C features + prominent bone protrusion ('cliff pattern').

Fig 3: Trochlear dysplasia classification.

References: Department of Radiology, Hospital de São João/ Porto 2013

The classic criteria for diagnosing trochlear dysplasia were defined for conventional radiographs. The "crossing sign" is a line represented by the deepest part of the trochlear groove crossing the anterior aspect of the condyles, assessed from lateral radiographs. The crossing sign is sensitive but not specific in diagnosing trochlear dysplasia. "Double contour sign" is a double line at the anterior aspect of the condyles and is seen if the medial condyle is hypoplastic.
The Merchant view is an axial radiograph of the patellofemoral joint obtained with the knee in approximately 45° of flexion. It is helpful for assessing the sulcus angle, the congruence angle, reduction of the patellofemoral joint, and for the presence of osteochondral fragments.

The sulcus angle is the angle formed between a line drawn from the center of the deepest portion of the trochlea to the medial femoral condyle and one to the lateral femoral condyle. This angle normally averages 138°. Increasing sulcus angles correlate with shallower or dysplastic trochlea.

**Fig. 4:** The sulcus angle is formed by the highest points of the medial and lateral femoral condyles and the lowest point of the intercondylar sulcus and is approximately 138 ± 6°. A sulcus angle > 145° is indicative of trochlear dysplasia.

**References:** Department of Radiology, Hospital de São João/ Porto 2013

Dejour et al found no angles greater than 145° in the control knees without patellar instability in their study, but 35% of the knees in the patellar instability group had normal trochlear angles, indicating that trochlear anomaly was situated at its superior origin.
The **congruence angle** is formed from a bisector of the sulcus angle and a line drawn from the center of the trochlea to the lowest, central portion of the patella. By convention medial angles are negative and lateral angles are positive. Angles greater than +16° denote lateral subluxation of the patella.

**Fig. 5:** Congruence angle. Line AO is the bisector of angle BAC. Line AD passes through the lowest point on the median ridge of the patella. Angle OAD is the congruence angle. If line AD falls to the medial side of line AO, the angle is expressed as negative degrees. If it falls to the lateral side of line AO, it is expressed as positive degrees.

**References:** Department of Radiology, Hospital de São João/ Porto 2013

Lateral trochlear inclination, trochlear facet asymmetry, trochlear depth and lateralization of the patella are used to evaluate the presence of trochlear dysplasia.

**Lateral Trochlear Inclination**

The inclination is the angle formed between the plane of subcondral bone of the lateral trochlear facet and a tangential line through posterior femoral condyles (the most superior section showing trochlear cartilage is selected for this measurement).

**An angle of less than 11° indicates trochlear dysplasia.**
Fig. 6: Lateral trochlear inclination. The angle between the posterior condylar axis and lateral trochlear facet. An angle of less than 11° is considered abnormal.

References: Department of Radiology, Hospital de São João/ Porto 2013

Trochlear Facet Asymmetry

This is the ratio of the length of the medial trochlear facet to the length of the lateral trochlear facet (measured at 3 cm above the tibiofemoral joint cleft).

A ratio of less than 0.4 is defined as indicating dysplasia.
Fig. 7: Trochlear facet asymmetry. A ratio of the medial to the lateral trochlear width less than 0.4 indicates trochlear dysplasia.

**References:** Department of Radiology, Hospital de São João/ Porto 2013

**Trochlear Depth**

This measures the inset depth of the trochlear groove (sulcus) relative to the average of the maximum anteroposterior distance of the medial and lateral femoral condyles (it is determined on axial images at the same level as trochlear facet asymmetry).

*A trochlear depth of less than 3mm is considered abnormal.*
**Fig. 8**: Trochlear depth. This measurement is calculated as the mean of the perpendicular distance between the medial and lateral margins of the trochlea to the posterior condylar axis minus the sulcus height measured in the same manner. A trochlear depth of less than 3mm is considered abnormal.

**References**: Department of Radiology, Hospital de São João/ Porto 2013

**Lateralization of the Patella**

This evaluates the lateral patellar displacement, measuring the distance between the lateral margin of the trochlea and the most lateral point of the patella.

**A distance greater than a 6 mm is indicative of trochlear dysplasia.**
Fig. 9: Lateral patellar subluxation. Axial MRI shows one way to assess lateral patellar subluxation, with a distance between the lateral margin of the trochlea and the lateral margin of the patella greater than 6mm considered abnormal.

**References:** Department of Radiology, Hospital de São João/ Porto 2013

**Patella Alta**

A patella alta, or high-riding patella, is a patella that is too high above the trochlear fossa and occurs when the patellar tendon is too long. Patella alta has been associated with recurrent dislocations, and about 25% of the patients with acute patellar dislocation have a patella alta. Patella alta is considered a main factor in patellofemoral misalignment because the patella does not become engaged within the trochlear groove until the knee is in more than 30° of flexion, which results in less osseous stability because the degree of flexion at which the patella engages in the trochlea is higher than that in a normal knee. Furthermore, knees with patella alta have reduced patellar contact areas when compared with knees with normal patellar height, and these reduced patellar contact areas lead to greater patellofemoral stress.

It is important to note, that patella alta is a normal anatomic variant, that is asymptomatic in most individuals. Nevertheless, the diagnosis is important because it increases the risk of patellar dislocation in conjunction with other factors.
Fig. 10: Insall-Salvati ratio. Sagittal MRI image demonstrates calculation of patellar height ratio, which is the patellar tendon length divided by the patellar length. A patellar height ratio of more than 1.3 indicates a high-riding patella (patella alta).

References: Department of Radiology, Hospital de São João/ Porto 2013

Patella alta can be measured in full extension on MRI using the Insall-Salvati ratio. In this method, the patellar height ratio is calculated by dividing the length of the patellar tendon (from the apex of the patella to its attachment on the tibial tuberosity) by the longest superoinferior diameter of the patella.

A patella height ratio of more than 1.3 is consistent with patella alta.
Lateralization of the Tibial Tuberosity

The position of the tibial tubercle is crucial for the inferolateral force vector of the patella. If there is excessive lateralization of the tibial tuberosity, the patella is pulled laterally during flexion. Therefore, excessive lateral displacement of the tibial tuberosity is a risk factor for lateral patellar dislocation.

The clinical exam alone is not reliable and imaging techniques are the only accurate way to measure the tibial tuberosity to the trochlear groove (TT-TG) distance.

The distance from the tibial tuberosity to the trochlear groove (TT-TG) is measured parallel to the tangential line through posterior femoral condyles by superimposing transverse images through the apex of the intercondylar notch and the tibial tuberosity.
Fig. 11: Tibial tuberosity to trochlear distance (TT-TG) distance. a) Overlaid axial CT images through the tibial tuberosity and mid-trochlear groove for calculation of the TT-TG distance. b) Post-processing software allows measurement of the TT-TG distance relative to a line parallel to the posterior condylar axis.

References: Department of Radiology, Hospital de São João/ Porto 2013

A TT-TG distance of more than 20 mm is nearly always associated with patellar instability, and is a measure for lateralization of tibia tuberosity more reliable than the Q angle because it is not dependent on patella position. Values of 15-20 mm are considered borderline and distances less than 15mm are considered normal.
Traditionally, the diagnosis of acute dislocations has been made based on patient history and physical examination findings. It is often difficult, however, to distinguish acute dislocations from more common injuries when the dislocation is occult and clinical assessment is limited by acute pain and swelling. It has been estimated that 50-75\% of cases are misdiagnosed at the time of initial clinical evaluation.

MRI is increasingly being used as an adjunct to conventional x-rays in the evaluation of musculoskeletal trauma because of its accurate characterization of soft tissue injuries. In cases of acute dislocations, the imaging findings lead to the diagnosis in clinically unsuspected cases and often identify associated abnormalities that may change management of patients.

In general, deformity or edema of the inferomedial patella and the lateral condyle, in conjunction with MPFL disruption and patellar lateralization, is diagnostic for recent patellar dislocation. Additionally, marked knee effusion and internal derangement of the knee may be present.

**Bone Contusion in Patella and Lateral Condyle (‘Kissing Contusions’)**

In nearly all patients (80-100\%) bone contusions of the lateral femoral condyle are seen, resulting from impaction of the patella.
**Fig. 12:** Bone edema after patellar dislocation with typical contusion of the lateral femoral condyle (yellow star) and effusion of the tissues surrounding the iliotibial band.  

**References:** Department of Radiology, Hospital de São João/ Porto 2013  
Bone contusions of the inferomedial patella are less frequent, ranging from 40-60% of patients.
Fig. 13: Kissing Contusions. 15-year-old female with knee pain. Axial PD FS MRI image demonstrates focal bone marrow edema involving the inferomedial aspect of the patella and the lateral aspect of the lateral femoral condyle, characteristic of prior lateral patellar dislocation injury. There is also almost complete/complete tear of medial patellofemoral retinaculum involving its patellar insertion. Knee effusion is also evident. References: Department of Radiology, Hospital de São João/ Porto 2013

Importantly, however, edema may resolve by the time imaging is performed.

Osteochondral Injuries and Intra-articular Loose Bodies

Osteochondral injuries are avulsion fractures or impaction injuries of the patella or femur with discernible irregularity of the osteochondral surface. Osteochondral injuries of the medial patella are seen in approximately two-thirds of the patients. Around 40% of the patients present with osteochondral lesions of the lateral femoral condyle.
Intra-articular bodies represent avulsed osteochondral fragments from the patella or the femoral condyle. They are found in as many as one third of the patients after patellar dislocation. They can cause symptoms and limit motion and are generally removed to relieve these symptoms and prevent secondary joint degenerative changes.

**Fig. 14:** Displaced osteochondral fragment. Sagittal PD MRI images after patellar dislocation with contusion show (a) bone bruise of the inferiomedial aspect of the patella (blue star) and (b) bone edema of the lateral femoral condyle, with suggestion of an osteochondral injury along the articular surface in this region. (c) A displaced osteochondral fragment is seen underlying the Hoffa's fat pad, with portion following both cartilage and bone signal intensity (red arrow).

**References:** Department of Radiology, Hospital de São João/ Porto 2013

MRI is particularly helpful when no loose bodies are seen on x-rays. The radiologist diagnosis is fundamental because surgery is indicated if lesions in the patella are larger than 1 cm$^2$, ideally performed within one week after the acute event.

Standard pulse sequences are highly reliable for detection of central cartilage defects in the patella if the lesions are large, with grade III or IV lesions, but is lower with grade I or II lesions (involving less than 50% of the cartilage thickness).
**Fig. 15**: Image depicts a high-grade full-thickness cartilage lesion (red arrow) (grade IV defect) of the central portion of the patella.

*References*: Department of Radiology, Hospital de São João/ Porto 2013

**Knee Joint Effusion / Hemarthrosis**

Knee joint effusion is a typical finding after patellar dislocation and will be seen in most patients, especially when imaging is performed immediately after the event, but the amount of fluid decreases over time. The presence of effusion is not specific and may also be associated with other conditions. Effusion is defined as a fluid depth of more than 4 mm in the suprapatellar recess on mid-sagittal images or fluid depth of more than 10 mm in the lateral recess on lateral sagittal images. If hemorrhage is present, fluid-fluid levels will be seen as a result of sedimentation of blood components.

Effusion is often absent in patients with habitual dislocations, because laxity of the medial stabilizers is protective against new ligamentous injury.
Injuries to Medial Patellar Stabilizers

The medial patellar restraints are commonly injured during lateral patellar dislocation and abnormalities are seen in 70-100% of cases of prior patellar dislocation on MRI. The MPFL and the medial patellar retinaculum may be difficult to differentiate, especially at their patellar insertion, where they blend with each other. The MPFL/medial retinacular complex is best seen on transverse and sagittal T2-weighted sequences as a well-defined, low signal-intensity band.

MRI findings of partial tears include intrasubstance and/or periligamentous edema, thickening, fiber irregularity, or partial discontinuity.

A full-thickness tear of a medial stabilizer is seen as complete disruption of the ligament and the presence of local soft-tissue edema. Wavy or retracted fibers surrounded by effusion are conspicuous for complete disruption. If there are multiple injuries involving all compartments, no intact low-signal-intensity ligament may be seen.
**Fig. 16:** Medial retinacular complex. Axial MRI demonstrates complete discontinuity and absence of visualization of normal medial retinacular fibers with a fluid-filled gap, consistent with a full-thickness tear (red arrow).

**References:** Department of Radiology, Hospital de São João/ Porto 2013

The MPFL is described as having three regions, a classification that is useful for reporting the site of tear. Injury may occur at the patella insertion (anterior third), midsubstance, or close to the femoral attachment (posterior third). Dividing the ligaments into three regions appears to be useful for reporting the site of the tear. Between 50% and 90% of the injuries to the medial ligaments involve the patellar insertion. It is also common to see multiple sites of injury to the medial ligamentous restraints. Injury in the femoral region can also occur in the form of an avulsion fracture of the medial femoral epicondyle, and this is a predictor of chronic instability, which is why the site of the tear may directly affect surgical planning.

**Patellar Subluxation and Tilt**

Following spontaneous patellar relocation or after reduction, the majority of patients will have some degree of persistent patellar subluxation or tilt due the accompanying medial retinacular injury and joint effusion. It is important to notice that these parameters may not have been abnormal prior to the injury.

Subluxation is defined as partial lateral dislocation of the patella from the femoral groove.

Patellar tilt is diagnosed by determining the lateral patellofemoral angle, which is calculated from lines drawn along the patella and along the condyles.

The patellofemoral angle is demonstrated as the angle between a line drawn along the lateral joint surface of the patella and a line drawn along the anterior aspect of the condyles. A patellofemoral angle opening laterally is considered normal, and an angle opening medially indicates patellar tilt. An alternative measurement of external patellar tilt is an angle formed by the line through the transverse axis of the patella and a line tangential to the posterior aspect of the femoral condyles.
Fig. 17: External patellar tilt without (a) and with (b) quadriceps contraction. The pathological threshold value is the same after quadriceps contraction, but the sensitivity and specificity of this measurement is improved.

References: Department of Radiology, Hospital de São João/ Porto 2013
With the quadriceps relaxed, the threshold value for pathologic tilt is 20° and the contraction of quadriceps can raise the percentage of patients with patellar instability that have this angle altered, helping to identify borderline cases.

Long-term changes in the patellofemoral joint may occur after chronic instability. With regard to such long-term changes, MR imaging demonstrates signs of early osteoarthritis and ligamentous ossifications of the medial patella in most cases.
Edema/Hemorrhage of Vastus Medialis

Patellar dislocation can also cause edema or hemorrhage of the vastus medialis obliquus adjacent to the MPFL.

Moreover, the vastus medialis obliquus can suffer disruption of its interstitial or insertional muscle fibers, and may be elevated from its attachment at the adductor tubercle.
Fig. 3: Trochlear dysplasia classification.

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**Fig. 4:** The sulcus angle is formed by the highest points of the medial and lateral femoral condyles and the lowest point of the intercondylar sulcus and is approximately 138 ± 6°. A sulcus angle > 145° is indicative of trochlear dysplasia.

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Fig. 16: Medial retinacular complex. Axial MRI demonstrates complete discontinuity and absence of visualization of normal medial retinacular fibers with a fluid-filled gap, consistent with a full-thickness tear (red arrow).

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**Fig. 17:** External patellar tilt without (a) and with (b) quadriceps contraction. The pathological threshold value is the same after quadriceps contraction, but the sensitivity and specificity of this measurement is improved.

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For a correct approach of patellar dislocation, a radiologist should be able to identify typical injury patterns and use the standard methods to quantify the risk factors for patellar instability.
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References