Lateral Patella Dislocations: History, Physical Exam, and Imaging

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Introduction

Most sports medicine physicians today consider lateral patella dislocations in the differential diagnosis of an acute knee injury in an athlete. In the recent past, this was not necessarily the case. Hughston, in 1964, felt that an athlete's report of a knee giving way was almost never attributable to a patellar dislocation [1]. Rather he opined "[these] immediate impressions are due to the unfortunate and erroneous idea that subluxation of the patella occurs predominantly in the female and is absent in the athlete." To this effect, acute first-time [primary] patellar dislocations have been shown to occur nearly equally across sexes, with greater than 60 % usually attributed to athletic activity [2–4].

Acute, primary lateral patellar dislocations occur primarily in the second decade of life [4, 5] at a rate of 29 per 100,000 [4]. They are associated with significant disability including pain or feelings of instability in 30–50 % of people [6, 7]. Associated injuries frequently occur, including medial patellofemoral ligament injuries in over 80 % of patients and associated ligamentous or meniscal injury in 31 % [8]. Though osteochondral fractures in over 50 % [7, 9–11] have been reported in the literature for primary and recurrent dislocations literature, a recent systemic review noted 24.7 % of patients had chondral and osteochondral damage in primary patella dislocations [12].

Recurrent patellar dislocation is a significant problem, reported in 15–44 % of patients treated nonsurgically [3, 6, 13, 14]. A prior dislocation is, in itself, a significant risk factor for having a recurrent dislocation, and risk progressively increases with subsequent dislocations. Fithian reported that patients with multiple dislocations, either ipsilateral or contralateral, had more than double the incidence of a future instability episode in comparison to first-time dislocators. Sex and positive family history also have a high correlation to recurrence risk. While first-time dislocations occur equally across sexes, recurrent dislocators tended to be female and tend to have a positive family history of patellar instability [4]. In addition, certain anatomic features have a high prevalence in patients with symptomatic patellar instability. These include trochlear dysplasia (>85 %), an increased tibial tubercle to trochlear groove (TT–TG) horizontal distance (56 %), patella alta (24 %), and patellar tilt (>70 %) of patients with instability [3, 5, 15, 16].

The history, physical exam, and imaging after an acute patellar dislocation should therefore be performed with the goals of (1) diagnosing the patellar dislocation, (2) recognizing associated

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injuries, and (3) recognizing any historical, congenital, or anatomic risk factors for recurrent dislocation.

History

Mechanism

The patient nearly always describes an indirect mechanism, where the limb and torso is internally rotated on a fixed tibia as the knee is held in a position of flexion and valgus. This knee position creates a strong lateral force on the patella. Less commonly, patients may report a dislocation after a direct blow to the patella [6, 7, 13, 17]. As the patella dislocates, patients experience a sudden giving way of the knee. Reduction of the patella is usually spontaneous and occurs as the patient contracts the quadriceps and straightens the knee. A manual reduction, when required, is usually accomplished by passively extending the knee and manipulating the patella medially. In very rare instances, the patella may impact into the lateral aspect of the lateral femoral condyle, requiring an open reduction [18].

Associated Injuries

The location and nature of the pain may help identify underlying injuries. Though the patella is dislocated laterally, pain is predominantly medially based due to the injury to the medial patella soft tissue structures. Pain located medially near the adductor tubercle of the distal femur may signify MPFL avulsion from its femoral insertion. The most common site of injury has varied in the literature; however, a recent review has shown the incidence to be patella attachment 54 % (range 13–75 %), midsubstance tears 12 % (range 0–30 %), and femoral attachment site 34 % (range 12–66 %) [19]. Further, pain described along either the lateral femoral condyle or medial patella may correlate with chondral injury sustained during patella relocation. Mechanical symptoms such as locking or catching suggest an obstruction to movement, such as loose bodies or a displaced meniscal tear.

Differential Diagnosis

The diagnosis of patella dislocation is most apparent when the patient actually describes the patella subluxing or dislocating. Other descriptions of the incident may be confounding. For example, twisting of the knee with sudden giving way and swelling is also seen with ACL injuries. Reports of the knee "giving out" is nonspecific and can be seen with other entities such as meniscal pathology, loose bodies or chondral injuries, or simply patellofemoral (PF) pain with bent knee activities. Patients may report feelings of instability with pain and crepitus, such as with descending stairs, without movement of the patella from its groove.

Physical Exam

The focused physical exam of the PF joint should be approached with the goal of establishing the diagnosis of patellar instability and identifying associated injuries and anatomic risk factors for instability. One should use a systematic approach including inspection; palpation; testing for laxity; assessing patellar position, stability, and tracking; and identification of cartilage injury. In addition to the PF exam, a comprehensive knee exam should also be performed (meniscal provocative maneuvers, measurement of range of motion, and varus-valgus, anterior-posterior knee stability, extensor mechanism integrity) to rule out concomitant injuries.

Inspection

Inspection of the knee should be performed in a standing, seated, and supine position. In the standing position, note whether the knees are directed straight forward. Knees turned inward may represent an underlying internal femoral torsion or external tibial torsion, one or both which may contribute to lateral tracking of the patella. Coronal plane alignment such as excessive *genu valgum* may also be observed, though is better evaluated with long leg standing alignment radiographs.

In a seated position, calculate the tubercle-sulcus angle, a measure of the relationship between the tibial tubercle and the trochlear sulcus. Described by Kolowich et al., the test assesses the distal force vector acting on the patella. With the knee flexed at 90°, a vertical line drawn downward from the center of the patella (which represents the center of the trochlear groove) should intersect the tibial tubercle in asymptomatic individuals. Though an exact upper value of normal has not been establish, a tibial tubercle lateral to this line, particularly if greater than 10°, may contribute to an increased lateral pull on the patella [20].

In a supine position, evaluate the skin for prior incisions and signs of trauma. The presence of an effusion is important to note. Typically a primary lateral patella dislocation is associated with dramatic swelling with disruption of the medial capsule and extracapsular extension.

Palpation

In systematic fashion, palpate all relevant patellofemoral joint structures and stabilizers, including the MPFL, tibial tubercle, patellar tendon, quadriceps tendon, and the patella itself. Pain or palpable defects should be correlated with injury mechanism and imaging findings. Next, apply compressive force to the patella, at different angles to concentrate the force on various regions of the patella and trochlea. Feel anteriorly for patellar crepitus during knee flexion and extension. Pain and/or crepitus, though not exacting in its relationship to underlying pathology [21, 22], should be correlated with imaging to rule out localized chondral injury.

Patellar Stability and Tracking

Patellar Apprehension Test: The patellar apprehension test is typically performed with the knee in full extension. A lateral directed force is applied to the patella. A positive test is confirmed by the presence of patient verbal reported apprehension and pain or a strong quadriceps muscle contraction resisting lateral patella translation. This is always compared to the contralateral (usually uninvolved) side for comparison. Ahmad modified the apprehension test and renamed it the "moving patellar apprehension test" (MPAT), where the second portion of the exam involved medial-directed pressure (rather than lateral), with a positive result defined as the patient expressing a sense of relief. He compared his results to the ability to dislocate the same patellae under anesthesia. He found a positive MPAT to be highly sensitive (100 %) and specific (88.4 %) for detecting patellar instability under anesthesia [23, 24].

Patellar Glide: Restraint of the patella to lateral translation is dependent on both bony and soft tissue structures as well as the degree of knee flexion (dictating patellar position in the trochlea) [17, 25, 26]. Of the soft tissue structures, the MPFL was found to provide 53 % and 60 % of the total restraint to lateral patellar translation in two biomechanical studies [25, 26]. The high rate of MPFL tears after patellar dislocations warrants evaluation of the medial restraints via lateral patellar glide. The exam is performed by grasping the patella and shifting it laterally, quantifying the maximum translation in number of patellar quadrants that are lateral to the lateral trochlear ridge (Fig. 2.1) [20].

Translation less than two quadrants is considered normal while two or more quadrants represent laxity of the medial restraints. When this is unilateral and associated with an acute injury, it likely represents an MPFL injury. More important than the absolute translation is the comparison to the opposite (uninjured) knee, whether there is a firm or soft endpoint, and the presence of an apprehension sign with this test.

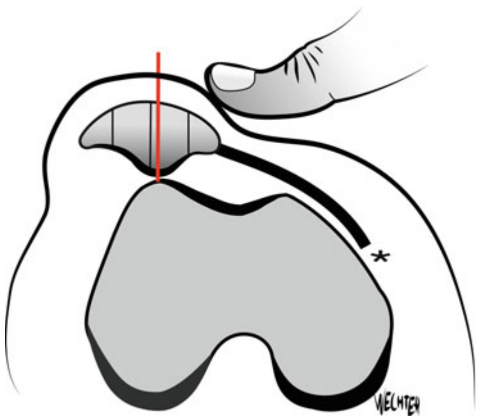

Fig. 2.1 Patellar glide: greater than two quadrants of lateral patellar translation, in relation to the lateral. Published with kind permission of John Wechter 2013. All rights reserved

Medial translation is assessed in similar fashion. Less than one quadrant of medial translation signifies a tight lateral retinaculum [20].

Patellar Tilt: Lateral tilt of the patella as assessed on overlapping CT images is seen in 83 % of patients with symptomatic patellofemoral instability [16]. On physical exam, the diagnosis is made by lifting the lateral patellar edge, attempting to manually restore it to a normal horizontal position. Inability to do so signifies the presence of a tight lateral retinaculum [27].

Patellar Tracking: In a supine position, the patient elevates their leg against gravity, then actively flexes and extends the knee slowly. As the knee nears full extension, the patella is normally seen to track slightly lateral with a smooth progression. More pronounced lateral movement of the patella in terminal knee extension has been termed "J-tracking" or the "J-sign." This phenomenon is not clearly understood [28] but is likely due to a combination of factors, most prominently the morphology of the trochlea and sagittal position of the patella in terminal extension (dictated by patella height and trochlear length) [29].

Comprehensive Knee Exam

A patellar dislocation may be accompanied by additional injuries to the knee; therefore, a thorough physical exam of the knee should include range of motion, an evaluation of ligaments, strength testing, and neurovascular assessment.

Imaging

Imaging studies are obtained to confirm the diagnosis, recognize associated injuries, and identify anatomic abnormalities that may have predisposed the patient to a patellar dislocation. Objective measurements of patella position and trochlear morphology are used to guide surgical planning.

Preferred Studies

Standard office radiographs and magnetic resonance imaging (MRI) are usually sufficient in achieving the above stated goals and are the mainstay in the workup following a patella dislocation. A combination of radiographs and MRI are employed to identify anatomic risk factors for dislocation including patellar tilt, height and translation, trochlear morphology, and tibial tubercle-trochlear groove alignment. Computed tomography (CT) is less commonly used, though it can be useful when femoral or tibial version is suspected as an underlying bony risk factor. Importantly, the complexity of patellofemoral instability demands that assumptions and decisions not be based on any single radiologic finding or measurement. Rather, a combined assessment of all variables, in conjunction with the history and physical exam, will help the clinician better understand the injury pattern, risk for re-dislocation, and guide further treatment.

Radiographs

Essential radiographic views include (1) AP of bilateral knees, with bilateral hip-to-ankle standing coronal alignment films; (2) weight-bearing true lateral of both knees in 20–30° of flexion; and (3) axial views of both knees in a low flexion angle (20–30°).

AP Bilateral Knees, AP Hip-to-Ankle Alignment Films

AP radiographs should be obtained in weight bearing. The focused view of the knees may show asymmetric patella height or evidence of a patellar dislocation such as a vertical patella fracture, though these findings are better seen on other views. The long leg hip-to-knee alignment films are primarily used for evaluation of coronal knee alignment. The method described by Stevens et al. [30] may be the simplest. The mechanical axis is drawn from the center of the hip to the center of the ankle and should pass through the central one-third of the tibial plateau. Deviation medially or laterally is deemed *varus* or *valgus* malalignment [30]. The *Q*-angle, representing the lateral vector of pull between the quadriceps and patellar tendon, is the angle between a line from the anterior–superior iliac spine to the center of the patella and a line from the patella to the tibial tubercle. Some authors have attributed *genu valgum* or increased *Q*-angle to recurrent patella dislocations or to abnormal patellar congruence [31, 32]; however, this has been strongly contested [33–36].

Lateral Radiographs

The lateral radiograph is typically taken with the knee flexed 30° in full weight bearing, which tensions the patellar tendon and leads to a statistically significant difference in patellar height when compared to non-weight-bearing films [37, 38]. The bent knee stance is necessary to separate the image from the opposite knee. Some have chosen to have a single leg stance with the opposite hip flexed to 90°; this can be useful to determine patella height in full extension, with quadriceps muscle tension fully engaged.

The lateral view is helpful for identifying trauma incurred during a patellar dislocation, such as transverse patellar fractures from a direct impact, or proximal/distal patellar pole avulsions. It also allows evaluation of patellar instability risk factors, specifically patellar tilt, patella alta, and trochlear dysplasia.

Patellar Tilt on the Lateral Radiograph

Patellar tilt is present in greater than 70 % of patients with symptomatic patellar instability [5, 16]. While Dejour and Burmann measured patellar tilt on the CT scan, Malghem described a classification system based on the lateral radiograph, assessing the relationship of the central patellar ridge to the lateral facet. With increasing patellar tilt, the central patellar ridge will become superimposed on, and eventually anterior to, the lateral facet [39] (Fig. 2.2).

Femoral-Based Patellar Height Measurement

The *Biedert patellotrochlear index* [40] (Fig. 2.3) is based on sagittal MR images. It measures the percent of patellar articular surface which is overlapped by the trochlea cartilage. A trochlea–patella cartilage engagement of less than 12.5 % (index <0.125) signifies too little overlap and is labeled patella alta, while greater than 50 % overlap (index >0.5) indicates patella infera.

Tibial-Based Patellar Height Measurement (Fig. 2.4)

The Insall-Salvati (IS) index is calculated by dividing the patellar tendon length over the greatest longitudinal dimension of the patella. The normal range is 0.8–1.2 with values greater than 1.2 considered patella alta. Since the IS index uses the tibial tubercle, it should not be used in patients with prior tibial tubercle osteotomies or in preoperative planning for their osteotomy. Additionally, the IS index should not be used when a long distal non-articular patellar pole is present, as this may underestimate the height of the *articular* portion of the patella [41].

The modified Insall-Salvati (MIS) index [41] describes the location of the articular portion of the patella in relation to the tibial tubercle. It is useful when a large distal patellar pole is present, as the calculation ignores the distal non-articulating portion of the patella. Values greater than two are deemed patella alta. The cutoff value of two, chosen in order to simplify calculation, was unfortunately found to miss 22 % of patella alta cases when compared to other indices [41].

The Caton–Deschamps (CD) index [42] measures the distance from the anterior–superior border of the tibia to the distal aspect of the patellar articular surface and divides this by the

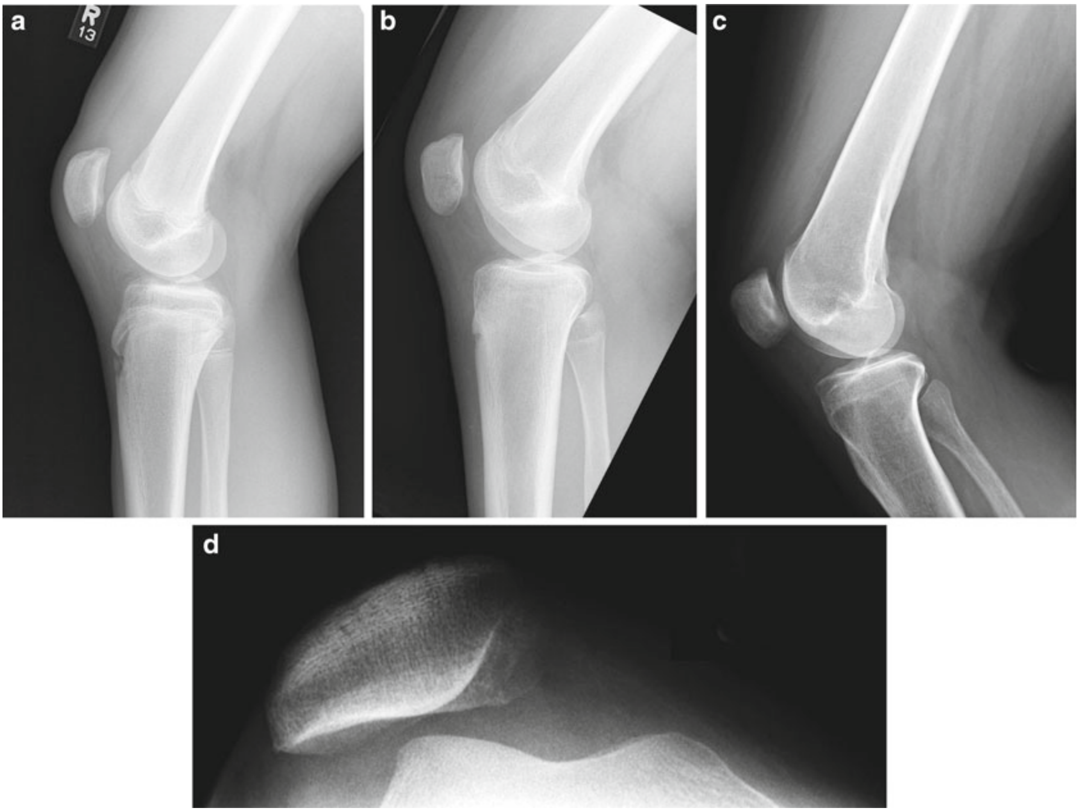

Fig. 2.2 Patella tilt evaluation as described by Malghem et al. [39]. (**a**) Position 1 normal position with the lateral facet artesior to the crest (median ridge). (**b**) Position 2 is mild tilt with the two lines (lateral facet and central ridge) superimposed; (**c**) Position 3 is major tilt with the lateral facet posterior to the crest; (**d**) Axial view of the patella at 45° that correcponds to image "c" (major tilt)

length of the patellar articular surface. The normal range is 0.6 and 1.2. Since the measurement does not use the tibial tubercle, this index can be used to evaluate patella height after a distalization of the tibial tubercle. Disadvantages include the occasional difficulty in identifying the anterior–superior portion of the tibia or the inferior margin of the patellar articular surface [24].

The Blackburne–Peel (BP) index [43] is calculated by first drawing a line along the tibial articular surface. The perpendicular distance from this line to the inferior margin of the patellar articular surface is divided by the length of the articular surface, with the normal range between 0.5 and 1.0. Dependence on the tibial plateau may be a downside, due to measurements being affected by tibial slope variations, as well the technical difficulty of obtaining an adequate lateral radiograph [24].

The most optimal patellar height index has not yet been established; however, certain generalizations can be made. First, for the sake of simplicity, tibial-based indices are more widely used than femoral-based indices, since they can be calculated at any degree of knee flexion, and calculations can be made on office acquired imaging. Understanding the strengths and limitations of these measurements may dictate which indices to use. For example, prior distalization of the tibial tubercle or abnormal morphology of the distal patellar pole limits the use of the IS ratio. For these instances, MIS may be used, though this was found to miss 22 % of patella alta as judged by other methods [41]. An overall comparison of

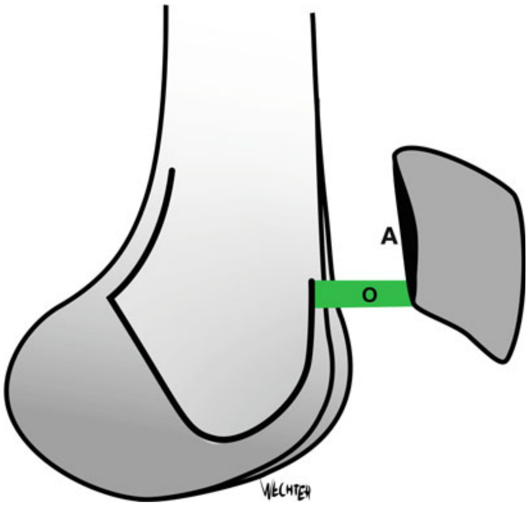

Fig. 2.3 *Biedert patellotrochlear index*: patellar–trochlear overlap (o)/patellar articular surface length (*A*) should be greater than 0.125 (12.5 %) [40]. Published with kind permission of John Wechter 2013. All rights reserved

the tibial-based indices was performed by Seil et al. [44]. He discovered a wide variation between the indices in classifying any given patella as alta, baha, or normal. He ultimately recommended the BP ratio since it was the most intermediate ratio in terms of frequency of diagnosing patella height as normal, alta, or baha. The best measurement may have yet to be developed. In 2011, Portner introduced a new tibial-based technique which may simplify the process [45]. He describes measuring the angle between a line drawn along the tibial plateau and the line from the inferior patellar articular margin to the posterior aspect of the plateau line [45].

Trochlear Dysplasia on the Lateral Radiograph

A true lateral radiograph of the knee (posterior condyles aligned) provides a thorough evaluation of the trochlea [37, 46] but requires an

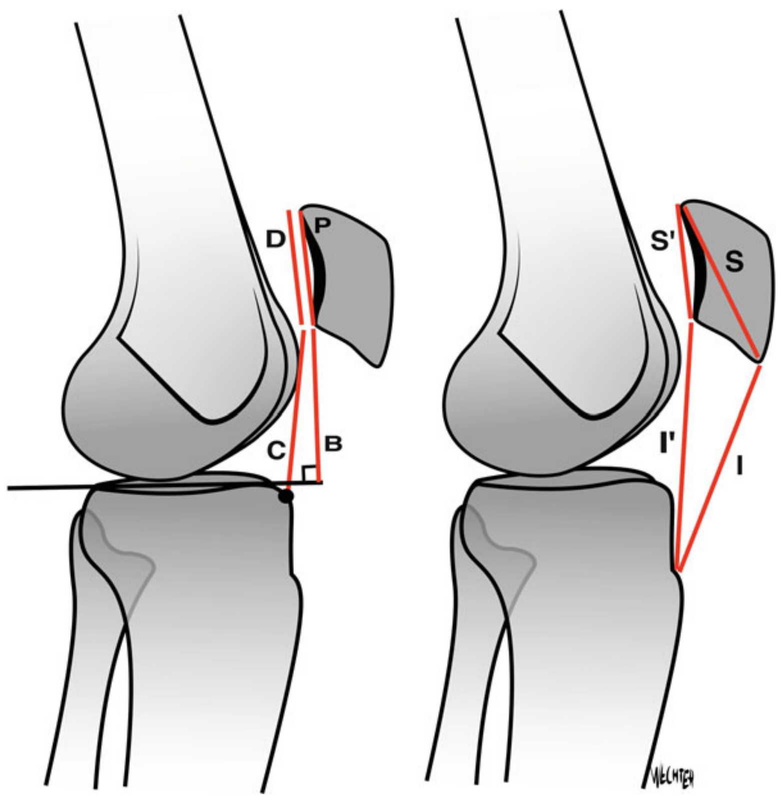

Fig. 2.4 Patellar height: measured on the lateral radiograph. *Bold line* = tibial surface. *Dot* = anterior–superior aspect of tibia. Caton–Deschamps index = *C*/*D*. Blackburne–Peel index = *B*/*P*. Insall–Salvati index = *I*/*S*. Modified Insall–Salvati = *I*′/*S*′. Published with kind permission of John Wechter 2013. All rights reserved

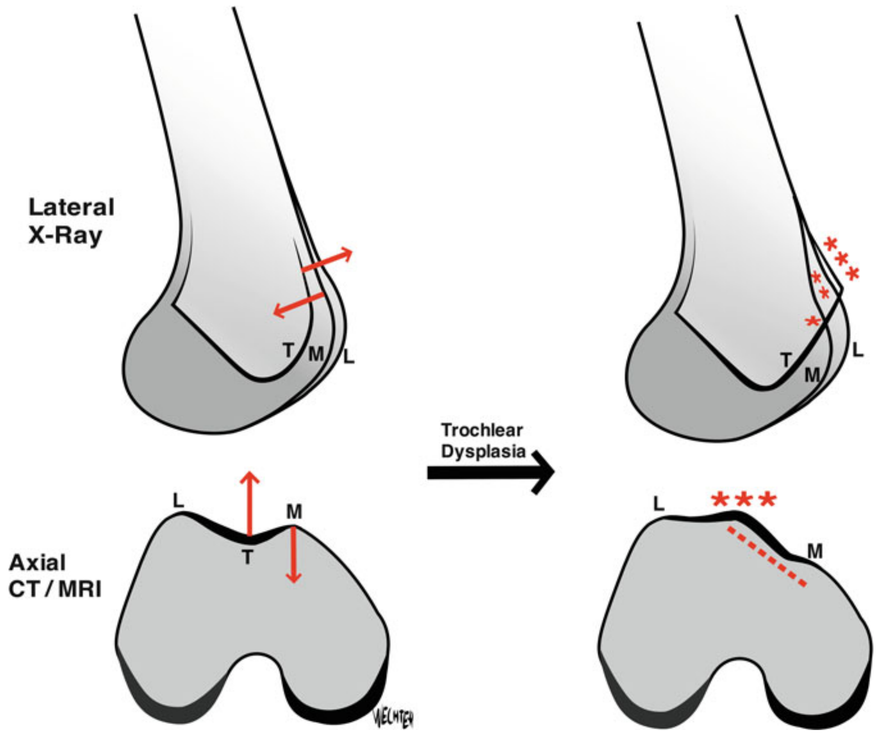

Fig. 2.5 Trochlear morphology [47]: the trochlear groove (T) should be posterior to the medial (M) and lateral (L) femoral condylar lines. In trochlear dysplasia, the trochlear groove is too prominent anteriorly (*anterior arrow*), which manifests as a "crossing sign" (*single star*) and sometimes a "supratrochlear" bump or "spur" (*triple star*). A hypoplastic medial femoral condyle (*posterior arrow*) manifests as a "double contour sign" (*double star*). A supratrochlear spur plus hypoplastic medial condyle creates a steep drop-off or "cliff sign" (*dotted line*) on the axial CT/MRI. Published with kind permission of John Wechter 2013. All rights reserved

understanding of the anatomy. With the femoral condyles superimposed at their distal and posterior aspects, the examiner follows three key lines from posterior to anterior, the lateral condylar line, medial condylar line, and trochlear groove line (Fig. 2.5).

Abnormal trochlear morphology is prevalent in >85 % of patients with symptomatic objective patellar instability [3, 5, 15, 16]. H. Dejour and his lyonnaise team were instrumental in describing markers of trochlear dysplasia as well as a classification system. He originally identified three classifications of trochlear dysplasia based on the level of the "crossing sign" on the lateral radiograph [48].

D. Dejour [49] later used the lateral radiograph in combination with the axial CT to introduce a four-grade classification of trochlear dysplasia [16] and ultimately included two new signs—the supertrochlear bump and double contour sign within this classification [49].

Figure 2.5 illustrates some of the radiographic signs of trochlea dysplasia, using two-dimensional imaging to describe a 3D process. These signs include a flattened or prominent trochlear groove, hypoplasia of the medial trochlear facet, the "crossing sign," a "supratrochlear spur sign," the "double contour sign," and the "cliff sign" (Fig. 2.5).

The crossing sign is found in 96 % of patients with a patellar dislocation and is pathognomonic of trochlea dysplasia. It is defined by a trochlear groove line which meets, or crosses anteriorly to, the medial facet line. This signifies that the trochlear groove is flat or even convex in relation to the medial trochlear facet [16].

The trochlear bump, or supratrochlear spur, is found in 66 % of patellar dislocations. It is defined by a trochlear groove line which is greater than 3 mm anterior to a line drawn along the anterior femoral cortex and represents a prominent trochlear groove [16]. This may contribute to instability by resisting patellar entrance into the proximal trochlea during early flexion [24].

The double contour sign is seen on the lateral radiograph as two separate lines, signifying a space between the medial and lateral trochlear facet lines on sagittal profile. This corresponds to a hypoplastic medial facet and was described by D. Dejour as occurring in high-grade trochlear dysplasia [15].

The "cliff sign" is seen on the axial MRI/CT. It is named due to the appearance of a prominent lateral trochlea in combination with a hypoplastic medial facet with a lack of cartilaginous continuity in the steep drop-off between the two condyles [47].

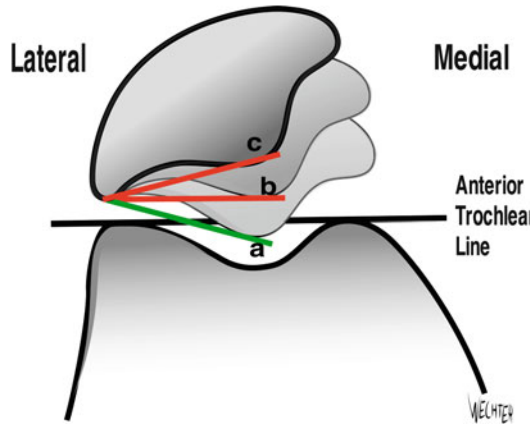

Fig. 2.6 Laurin's lateral patellofemoral angle [51]. Laterally, the anterior trochlear line should diverge from the lateral facet line (*line a*). With lateral patellar tilt, the two lines become parallel (*line b*) or converge laterally (*line c*). Published with kind permission of John Wechter 2013. All rights reserved

Axial Radiographs

Axial radiographs were first reported by Settegast in 1921 [50] and allowed analysis and measurement of patella position in relation to the trochlear groove. There are over a dozen methods described, with Laurin [51] and Merchant views [52] most used in the USA. Low angle of knee flexion becomes important when evaluating the trochlea, as lesser degrees of flexion will show the proximal portion of the trochlea, where dysplasia of the trochlea is most manifest. Axial views on plain radiographs have been criticized for image distortion and lack of reproducibility. With the advent of serial slicing on axial MRI and CT, which allows visualization of the posterior condylar line, more precision has been afforded for the measurement of tilt. Axial radiographs, however, have remained an easy and affordable clinical imaging test to include in the outpatient evaluation of PF disorders.

Axial Radiograph Techniques

Laurin's technique [51] describes the knee at 20° flexion, with the X-ray beam aimed proximally, parallel to the patellofemoral joint. The cassette is held 12 cm proximal to the knee, perpendicular to the X-ray beam, and is pushed into the thigh. In obese or muscular patients, the cassette may need to be moved more proximally or pushed more firmly into the thigh.

Merchant's technique [52] was originally described with the knee flexed at 45°, with the X-ray beam aimed distally and elevated 30° from the femur. The cassette is held over the anterior tibia, perpendicular to the beam. More recently, 30 and 60° of knee flexion with a similar beam angle have been analyzed and normal parameters of patella position described.

Patellar Tilt on Axial Radiograph

Laurin's lateral patellofemoral angle [53] (Fig. 2.6) is calculated on the 20° flexion view and consists of the angle between a line drawn across the anterior aspects of the trochlear facets and a second line drawn along the lateral patellar facet. Laurin found that 97 % of normal patients had lateral diversion of the lines, whereas all patients with patellar subluxation had either parallel or converging lines, implying increased lateral patellar tilt. A meta-analysis by Smith [54] found high heterogeneity across studies in the ability for this measurement to distinguish between normal controls and patients with patellar instability.

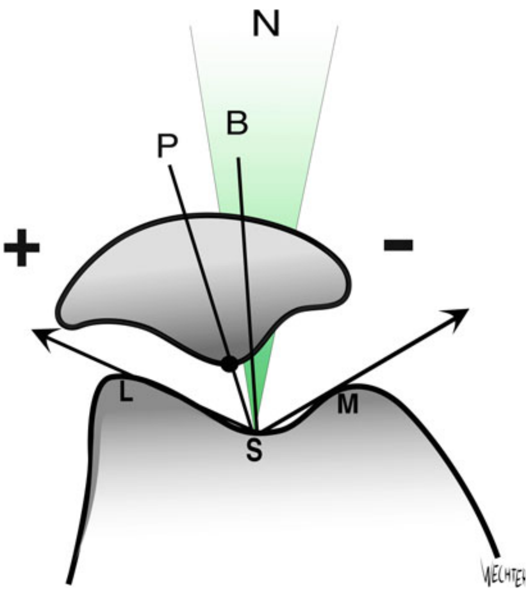

Fig. 2.7 Merchant's congruence angle [52]: quantifies medial (−) and lateral (+) patellar translation. The sulcus angle is drawn from the apices of the medial (*M*) and lateral (*L*) trochlear facets to the lowest point of the trochlear sulcus (*S*). Two lines are drawn upward from the sulcus apex, one which bisects the sulcus angle (*B*) and the other connecting to the central patellar ridge (*P*). The angle between *B* and *P* is the congruence angle. Normal (*N*) is −6° ± SD 11°. Published with kind permission of John Wechter 2013. All rights reserved

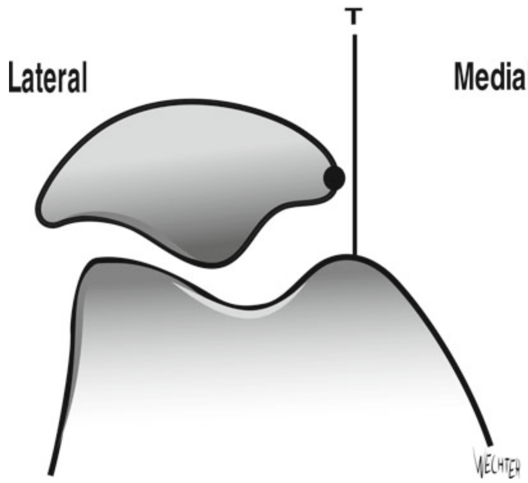

Fig. 2.8 Laurin's lateral displacement [51]. The medial edge of the patella (*dot*) should be even with or medial to the medial trochlear apex (*T*). Published with kind permission of John Wechter 2013. All rights reserved

Patellar Translation on Axial Radiograph

Merchant's congruence angle [52] (Fig. 2.7) is the angle between two lines drawn upward from the sulcus apex, one which bisects the sulcus angle and the other connecting to the central patellar ridge. Lateral and medial translation of the patellar ridge in relation to the sulcus is labeled in positive and negative degrees, respectively. Merchant found the average congruence angle in normal controls to −6° (SD 11°) compared to patellar instability patients who averaged +23°. Smith's meta-analysis [54], however, was unable to determine the reliability or validity of this measure, due to "recurrent methodologic limitations" across studies.

Lateral patellar displacement (Fig. 2.8) was defined by Laurin [51] as the relationship of the medial edge of the patella to the summit of the medial trochlear facet. They found that the medial patellar edge was lateral to the medial facet summit in 50 % of patients with lateral patellar instability compared to only 3 % of the normal controls.

Stress radiographs may be useful when there is a high clinical suspicion of lateral patellar instability despite the standard axial radiographs being normal. Teitge [55] applied 16 lb of laterally directed force to the patella and found that lateral patellar excursion >4 mm more than the contralateral knee was correlated with recurrent patellar dislocations.

Trochlear Morphology on Axial Radiograph

The sulcus angle is calculated as the angle between the apices of the medial and lateral trochlear facets and the deepest portion of the trochlear groove. Merchant, with the knee in 45° of flexion, found normal subjects to have a mean sulcus angle of 138° with a standard deviation of 6° [52]. Values greater than 144° represent a flattened trochlea groove. In a meta-analysis by Smith et al. [54], sulcus angle was able to discriminate well between healthy controls and patients with patellar instability. Another study showed higher sulcus angles (flatter sulcus) correlated well with other markers of trochlear dysplasia, in particular increased patellar tilt and patella alta [56].

Magnetic Resonance Imaging

Identifying Trauma

Evaluation of the trochlear cartilage, patellar cartilage, and medial and lateral aspects of the femoral condyles is performed on both the axial images and the coronal/sagittal reconstructions. The presence of reciprocal lesions of the lateral femoral condyle and medial patellar facet imply an impaction injury sustained during patellar relocation and are pathognomonic for a lateral patella dislocation. Evaluate the mid-substance of the MPFL as well as its patellar and femoral insertions to identify the site of injury. Sagittal and coronal images are inspected to identify injuries to the meniscus, tibio-femoral joint, cruciate ligaments, and tibial–collateral and fibular–collateral ligaments.

Trochlear Analysis on MRI

D. Dejour's four-grade classification was originally based upon radiographs and CT; however, today, MRI is widely used in place of CT. A 2012 study by Lippacher and D. Dejour comparing the MRI and lateral radiograph found fair inter- and intra-observer reliability in classifying dysplasia as A, B, C, or D and excellent reliability in classifying dysplasia as low grade (Type A) or high grade (Types B, C, D) [57].

Increasing emphasis is being placed on a more detailed description of trochlear morphology. Several measurements are used, all of which essentially examine the relationship of the height of the medial and lateral trochlea to the sulcus. These MRI measurement schemes include the following:

Trochlear groove depth (Fig. 2.9): A shallow trochlear groove is a radiographic characteristic of trochlear dysplasia and patellar instability [16, 58]. On MRI, groove depth is measured on the axial sequence. First, a line is drawn along the posterior aspect of the femoral condyles. Then, at a level 3 cm proximal to the tibio-femoral joint, three perpendicular lines are drawn extending anteriorly from the posterior condyle line, to the apices of the medial and lateral trochlear facets, and to the deepest point of the trochlear groove. The length of the trochlear groove line is subtracted from the average length of the facet lines, to yield the trochlear depth. A trochlear groove depth less than 3 mm on the MRI is highly correlative with the presence of trochlear dysplasia on the lateral radiograph [59, 60].

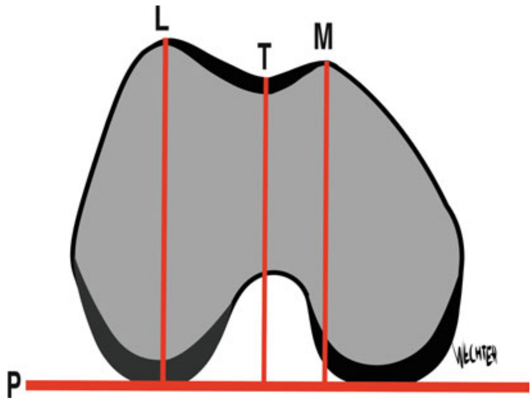

Fig. 2.9 Trochlear groove depth: $((L+M)/2)-T$. P—posterior condylar line; L—lateral facet height; M—medial facet height; T—trochlear groove height. Published with kind permission of John Wechter 2013. All rights reserved

Lateral trochlear inclination measures the angle of the lateral trochlear facet in relation to the posterior condylar line, while the *trochlear facet ratio* compares the widths of the medial and lateral trochlear facets at a level 3 cm proximal to the tibio-femoral joint. MRI studies by Diederichs and Pfirrmann found lateral trochlear inclination <11° and a disproportionately small medial trochlear facet (medial:lateral facet ratio <40 %) to correlate well with a trochlear bump >3 mm and a positive crossing sign, both which are established radiographic markers of trochlear dysplasia [59, 60].

The *sulcus angle* (Fig. 2.7), measured on radiographs as the high points of the trochlear facets to the deepest point of the sulcus, has an unclear role in MRI evaluation. While it has been found to correlate with patellar instability [10], one study found inconsistency between radiographic and MRI measurements of sulcus angle [61] and another found poor intra and inter-observer reliability [62]. Technique may play a factor, as the sulcus angle was found to be larger (flatter trochlea) when measurements were made along the articular cartilage as opposed to the subchondral bone [63].

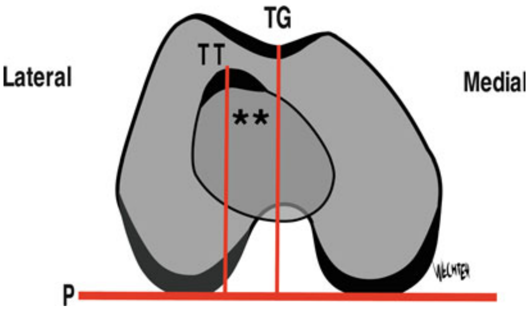

Fig. 2.10 Tibial tubercle to trochlear groove distance (TT–TG) [16]: the horizontal distance (*double asterisk*) between two perpendicular lines extended from the posterior condylar line (*P*); one to the anterior aspect of the tibial tubercle (TT) and the other to the deepest portion of the trochlear groove (TG). Published with kind permission of John Wechter 2013. All rights reserved

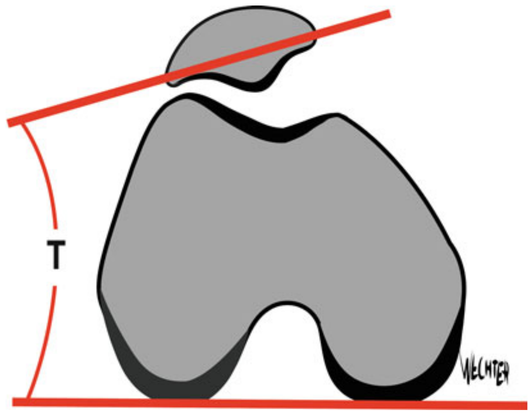

Fig. 2.11 Patellar tilt (MRI/CT): the angle between a line drawn along the posterior condyles and another drawn through the patellar axis. Published with kind permission of John Wechter 2013. All rights reserved

Alignment Evaluation on MRI

Tibial Tubercle to Trochlear Groove Distance (Fig. 2.10)

Increased TT–TG distance is a risk factor for patellar instability [16]. The measurement is made on a CT or MRI, using superimposed images. It is defined as the horizontal distance from the anterior aspect of the tibial tubercle to the deepest part of the proximal trochlear groove on the first axial image showing a complete cartilaginous trochlea [9, 64]. TT–TG values as low as 12.6 on MRI [9] and 14.4 on CT [64] and as high as 20 mm [16] have been deemed pathologic cutoffs, correlating with symptomatic patellar instability. One reason for this wide variation may be the wide heterogeneity in soft tissue and bony landmarks used for measuring the TT–TG distance [65]. One study found improved inter- and intra-observer reliability when using the center of the patellar tendon as the tibial landmark, rather than the anterior aspect of the tibial tubercle [65]. Patient body size should also be taken into account when interpreting TT–TG, since it is a distance rather than a ratio.

Patellar Position on MRI

Patellar Tilt (Fig. 2.11)

Lateral patellar tilt greater than 20° has been found to be disproportionately present in patients with symptomatic lateral patellar instability, when compared to normal controls [5, 16]. The angle is measured between a line drawn along the posterior condyles and a line through the patellar axis.

Referencing off the posterior condyles may be superior to the radiographic technique, where patellar tilt is measured in relation to a line drawn anteriorly across the trochlear facet apices. This is an area prone to variation in trochlear dysplasia, such as a hypoplastic facet or a prominent trochlear bump.

Patella Alta: A high riding patella is established as a contributing factor in lateral patellar instability and is typically calculated using the above described radiographic techniques: IS, CD, BP, and femoral-based indices (Figs. 2.3 and 2.4). These same indices can potentially be applied to the lateral MRI, with the advantage that anatomic landmarks, particularly the distal insertion of the patellar tendon, and the distal extent of the patellar articular surface, can be visualized better on the MRI. Interpretation should consider, however, that full knee extension and a relaxed quadriceps could cause the patellar tendon to “sag” [66] and potentially effect the measurement. One study compared the IS ratio using radiographs and MRI and found no significant difference [66]; however, another study found a small but significant decrease in patellar height when using MRI and CT, as compared to radiographs.

They recommended that when using the IS ratio, 0.13 and 0.10 should be added for the MRI and CT, respectively. For the BP ratio, 0.09 should be added for the MRI only [67].

Conclusion

Acute lateral patellar dislocations carry significant morbidity, due to pain and associated injuries, as well as the risk for recurrence. The history and physical exam are used in conjunction with radiographs and MRI to confirm the diagnosis and identify injuries to the patellofemoral joint and adjacent structures. Anatomical measurements, made on physical exam and via imaging studies, are helpful for predicting recurrence risk and for planning surgical treatment.

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