MENTORS IN ORTHOPEDICS

CLINICAL EXAMINATION OF KNEE INSTABILITY

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SUMMARY

Background: The knee joint lacks inherent bony congruency and relies on a complex network of ligamentous and capsular structures for stability. While magnetic resonance imaging serves as a primary diagnostic tool, clinical examination remains essential for identifying multi-ligamentous and rotatory instabilities that may be under-detected by standard imaging protocols.

Objective: This review aims to delineate the anatomical contributions to knee stability and provide a systematic framework for the clinical diagnosis of straight, rotatory, and patellofemoral instabilities through specific physical examination maneuvers.

Key Points: Tibiofemoral instability is categorized into straight and rotatory patterns. Straight instabilities, including varus, valgus, anterior, and posterior laxity, are assessed using stress tests at 0° and 30° of flexion to differentiate between isolated and combined ligamentous injuries. Anterior cruciate ligament deficiency is primarily evaluated via the Lachman and pivot shift tests, while the posterior drawer and sag tests identify posterior cruciate ligament compromise. Rotatory instabilities involve abnormal subluxations of the tibial condyles relative to the femur. Anteromedial, anterolateral, and posterolateral rotatory instabilities require specialized maneuvers, such as the Slocum, jerk, and dial tests, to assess the integrity of the posteromedial and posterolateral corners. Patellofemoral assessment focuses on the Q-angle, patellar tracking (J-sign), and the apprehension test to evaluate medial patellofemoral ligament integrity and trochlear morphology.

Conclusion: A comprehensive understanding of knee anatomy and biomechanics is fundamental for accurate clinical diagnosis. Systematic physical examination is the primary method for identifying complex injury patterns, which is critical for effective surgical planning and preventing ligamentous reconstruction failure.

KEYWORDS

Knee Joint; Joint Instability; Physical Examination; Anterior Cruciate Ligament Injuries; Posterior Cruciate Ligament

INTRODUCTION

The knee joint lacks inherent bony stability and is dependent on the ligamentous structures attached around the knee to provide stability. Knee instability is a complex problem, accentuated by presence of multiligamentous injuries.Although MRI is the gold standard diagnostic modality for diagnosis of acute as well as chronic knee instabilities, a thorough and detailed clinical examination of the injured knee is of utmost importance, especially in diagnosis of rotatory injuries as these injuries can sometimes be missed even on a MRI. Knee instability can be broadly classified into tibiofemoral instability and patellofemoral instability. Tibiofemoral instability is further subdivided into straight and rotatory instability. In straight instability there is abnormal gliding between tibia and femur either in the frontal or the sagittal plane.In rotatory instabilities there is abnormal forward or backward translation and rotation of the tibial condyle relative to femoral condyle. It is of utmost importance to understand the contribution of anatomic structures to the stability of the knee. By being thorough in the anatomy of the knee esp the posteromedial and the posterolateral corner of the knee an orthopedic surgeons ability to clinically diagnose patterns of knee injuries and various types of knee instabilities can be greatly enhanced.

The knee joint is unique as it lacks the inherent bony stability found in the other joints of the lower extremity like the hip or the ankle joint. It is not a true hinge joint and the tibia navigates in a helical manner on the femoral condyles.

The knee joint stability is provided primarily by the shape of the condyles, the menisci and ligamentous structures.

The 4 ligaments including the anterior cruciate ligament (ACL), posterior cruciate ligament(PCL), medial collateral ligament (MCL) and the lateral collateral ligament (LCL) play major role in providing primary stability in the sagittal & frontal planes. The muscles & the tendons acting around the knee provide secondary dynamic stability.

ASSESSMENT

A detailed history and thorough physical examination are the foundation stones on which a sound practice of Orthopedic Sports medicine is built. Detailed history should include a description of injury and symptoms of the patient. Hearing or feeling a “pop” followed by a fall or inability to continue sporting activity and subsequent swelling of the knee (hemarthrosis) within 2 hours is quite suggestive of an acute ACL injury. With Chronic ACL injury patient usually presents with complaints of feeling unstable or “giving way” during physical activites especially twisting movements and may have difficulty in coming down a hill or walking on uneven surfaces. Age, occupation, lifestyle, level of sporting activity, and past history all should be taken into consideration while planning subsequent management. When evaluating a patient for knee instability, it is of utmost importance to understand the contribution of anatomic structures to the stability of the knee for making an accurate clinical diagnosis. Apart from testing the injured knee for instability an assessment of range of movement (ROM), limb alignment and distal neurovascular status should also be done. Some clinicians feel it is a good clinical practice to evaluate the uninjured knee first especially in acutely injured knees. It not only gives us a general feel of normal ligament tension in that particular individual, but also helps in relaxing the patient, winning patients trust and

thus preventing reflex resistance from patient & apprehensive tightening of dynamic structures while examining the injured knee.

In acute injuries plain radiograph of the knee should always be done which can reveal fractures, dislocations and osteochondral fragments. However MRI remains the gold standard diagnostic modality for confirmation of both acute as well as chronic ligamentous injuries. It is important to understand that MRI images obtained in general practice may not have the resolution to clearly delineate the full extent of the injury to the posteromedial structures & posterolateral structures of the knee which gives rise to rotatory instabilities. Hence physical examination remains the cornerstone of diagnosis of such injuries. [1]

Ligamentous injuries leading to Instability can be caused by direct or Indirect trauma. The most frequent mechanism of injury is “noncontact,” involving activities like sudden change in direction, twisting, jumping, and abrupt deceleration.

Knee instability can be broadly classified into 2 categories :

- Tibiofemoral instability.
- Patellofemoral Instability.

Tibiofemoral Instability can further be subdivided into :

- Straight Instability
- Rotatory Instability.

Straight Instability

Straight instability is defined as :

Increased angular movement between the tibia & femur in frontal plane (Abduction/Valgus) or (Adduction/Varus)

Or

Increased Gliding movement between tibia and femur in sagittal plane.

There are 4 types of Straight instabilities.

- Varus Instability
- Valgus Instability
- Anterior Instability
- Posterior Instability

Rotatory Instability

The posterior cruciate ligament located at the centre of the joint, forms the main axis around which flexion-extension & rotation takes place. In Rotatory instabilities the tibia rotates abnormally on the femoral condyle. The PCL is usually intact in rotatory instabilities.

There are 3 types of rotatory instabilities:

Anteromedial Rotatory Instability (AMRI)

In AMRI there is abnormal forward translation & external rotation of the medial tibial condyle relative to medial femoral condyle. The lateral tibial condyle maintains its normal relationship with the lateral femoral condyle.

Anterolateral Rotatory Instability (ALRI)

In ALRI there is abnormal forward translation & internal rotation of the lateral tibial condyle relative to lateral femoral condyle. The medial tibial condyle maintains its normal relationship with the medial femoral condyle.

Posterolateral Rotatory Instablity (PLRI)

In PLRI there is abnormal backward translation & external rotation of the lateral tibial condyle relative to lateral femoral condyle. The medial tibial condyle maintains its normal relationship with the medial femoral condyle.

STRAIGHT INSTABILITY

Varus Instability

The Lateral Collateral Ligament LCL is the primary restraint against Varus instability at all flexion angles. The posterolateral complex PLC provides secondary restraint against Varus . The LCL is rarely injured in isolation. Usually LCL tear is a part of multi ligamentous injury with symptoms depending on involvement of PLC & severity of injury. Varus instability is clinically assessed by Varus stress test done at 30 and 0 degrees of knee flexion.

Varus instability at 30 degrees of Knee flexion is hallmark of LCL injury.

Varus instability at full extension (0 degrees flexion) is suggestive of combination injury (LCL+PLC+ PCL with or without ACL injury)

Varus instability at both 0 & 30 (with max at 30 degrees) is suggestive of LCL+PCL injury. [2]

Varus Stress Test at 0 & 30 degrees.

Figure 1: Varus stress test at 30° knee flexion and full extension

Technique: Patient lies supine with the hip slightly abducted and over the side of the table. The examiner place one hand over the Lateral femoral condyle and the other hand at the proximal end of the tibia and the tibia is held in slight Internal Rotation. The Knee is held in 30 degrees of flexion and a Varus force is applied across the joint line.

The Knee is then extended to 0 degrees of flexion and the Varus force is again applied. The test is considered positive if the lateral opening of the joint is more than the contralateral side. Opening of joint 0-5 mm more than

normal side is graded as Grade 1 instability. Opening of 6-10 mm is considered as Grade 2 and any opening more than 10 mm is considered as Grade 3 instabilty.

Trias believed that the examiner should not only record the amount of joint opening but also the quality of the endpoint. [3] Therefore in Trias classification Grade 1 instability is one which allows for minimal joint opening with pain usually at the site of tear of LCL.

Grade 2 instability allows some opening of the joint but has a firm end point whereas

In Grade 3 instabilty the joint opens up unlimitedly(proportional to applied force) with no distinct endpoint.

Valgus Instability

Anterior fibres of MCL act as chief restraint against Valgus instability accounting for 78% medial stability at 25 degrees flexion & 57% at 5 degrees flexion. [4]

The Deep MCL , POL (Posterior Oblique Ligament) & ACL act as secondary stabilisers esp near full extension.

Valgus instability at 30 degrees of knee flexion is gold standard of MCL injury.

Valgus instability at 0 degrees suggestive of MCL, Posteromedial corner (PMC)/ Posterior Oblique Ligament (POL) + PCL injury.

Valgus Stress Test at 0& 30 degrees

Figure 2: Valgus stress test at 30° knee flexion and full extension

Technique: Patient lies supine with the hip slightly abducted and over the side of the table. The examiner place one hand over the Lateral aspect of the knee and the other hand holds the leg at the ankle. The tibia is held in slight External Rotation. The Knee is held in 30 degrees of flexion valgus force is applied across the joint line and stability is assessed.

The Knee is then extended to full extension (0 degrees of flexion) and the Valgus force is again applied.

Just like Varus Stress test while grading the Valgus test one should assess both the amount of joint opening as well as the quality of the end point and compare it with the contralateral knee.

Grade 1 less than 5 mm medial joint opening with solid end point.

Grade 2 5-10 mm of medial joint opening with good end point.

Grade 3 More than 10 mm of medial joint opening with mushy end point. [5]

Anterior Instability

Anterior cruciate ligament acts as primary restraint against excessive forward translation of tibia on the femur. ACL is the most commonly injured knee ligament. The mechanism of injury is usually sudden deceleration, hyperextension or pivoting on a fixed foot. [6]

Demonstration of abnormal anterior tibial translation in relation to the femur (Lachman & Anterior Drawer test) is the basis for clinical diagnosis of ACL injury.

It has been demonstrated in vitro & vivo studies that when ACL is sectioned maximum amount of anterior translation occurs at 30 degrees of knee flexion. When MCL is also sectioned it increases the anterior translation at 90 degrees but not at 30 degrees thus indicating that at 30 degrees of flexion ACL is the chief restraint for forward translation of tibia & thus Lachman test has maximum specificity to detect ACL deficiency and is the clinical examination of choice for detection of ACL injuries. [7]

Dehaven reported that in acutely injured knees Lachman test was positive in 80 % patients examined without anesthesia and in 100 % of knees examined under anesthesia. On the contrary Anterior Drawer test was positive in only 10 % of pts examined without anesthesia and in 50% examined under anesthesia. However when evaluating chronic injuries both tests have shown greater diagnostic values in detecting ACL deficiency. [8]

Lachman Test

Figure 3: Lachman test for anterior instability

For assessment of ACL injuries the knee is placed in 30 degrees of flexion and neutral tibial rotation. One must be sure that the tibia is not posteriorly subluxated at the start of the test to avoid misdiagnosing ACL injury in a PCL deficient knee. The femoral condyles are palpable 1 cm posterior relative to the tibial plateau. Bucket handle tears of medial meniscus and scarring of torn ACL on the PCL can restrict forward translation of tibia giving false negative results.

Technique: Patient lies supine on the table with the knee in 30 degree flexion and tibia in neutral rotation. One hand of the examiner stabilizes the distal femur and with the other hand firm pressure is exerted on the posterior aspect of proximal tibia to induce forward translation. Visible or proprioceptive anterior translation of tibia with a soft or mushy end point indicates a positive result. [9]

1-5 mm of anterior translation is defined as Grade 1 injury,6-10 mm as Grade 2 and more than 10 mm is defined as Grade 3 injury. The quality of end point is also taken into consideration being graded as firm, soft or absent. This grading system is relative to normal contralateral knee.

The Anterior Drawer Test

Before the introduction of Lachman test, Anterior Drawer test was the usual clinical test done to assess ACL deficiency. In an acutely injured and swollen knee the prerequisite of bending the knee 90 degrees , hamstring spasm & secondary stabilization of anterior translation by MCL resulted in false negative results. In literature in an alert patient sensitivity of Anterior drawer test for diagnosing ACL deficiency has been reported to be between 22-95%. [10],[11]

Technique: The patient lies supine on the table with hip flexed to 45 degrees , knee flexed to 90 degrees & the tibia in neutral rotation. The examiner can sit on the foot of the patient to keep the leg stabilized. Patient must be encouraged to relax his hamstrings. The relationship of tibial plateau being anterior to femoral condyle should be ascertained to avoid misdiagnosis in a PCL deficient knee. Once the patient is fully relaxed , grasp the upper tibia with both hands with index fingers palpating that hamstrings are relaxed and place the thumbs over the anterior joint line. A forward translation force is applied and the movement of the tibia along with quality of the end point is noted and graded in comparision to the contralateral leg .Sometimes an audible snap or a palpable jerk can be felt along with excessive forward movement of tibia when an anteriorly directed force is applied .(Finochietto jumping sign).This is indicative of a meniscal lesion along with an ACL tear.

Anterior Drawer Test in External Rotation: SLOCUM test

Figure 4: Anterior drawer test in neutral rotation, external rotation (SLOCUM test) and internal rotation of tibia

Maintaining the hip & knee flexion the leg and the foot are now externally rotated. An anteriorly directed force is again applied in the same manner and the movement of the tibia is noted. In case of an isolated ACL tear the Anterior drawer test is negative. However if there is still anterior translation of tibia & Anterior Drawer test is still positive it is indicative of an associated injury to medial compartment ligaments /Posteromedial corner PMC comprising of Medial Collateral ligament MCL, Posterior Oblique ligament POL, meniscotibial ligaments, post horn of medial meniscus & Oblique Popliteal ligament.

The basis of the test is that when the tibia is externally rotated the PMC acts as secondary restraint to anterior translation of tibia in an ACL deficient knee. Thus a positive test result means that the external rotation of tibia has not been able to diminish anterior translation of tibia & is suggestive of injury to PMC resulting in Anteromedial rotatory instability.(AMRI)

Anterior Drawer Test in Internal Rotation

In patients with medial ligamentous injury on internally rotating the tibia the Anterior Drawer test is negative because internal rotation of tibia tightens the PCL & prevents any forward translation of tibia. However if the Anterior drawer test is still positive it is indicative of PCL tear.

Pivot Shift Test

Figure 5: Pivot shift test. With knee in extension and tibia in internal rotation an axial load and valgus force is applied as the knee is fixed. At 30°-40° of knee flexion the tibila subluxation reduces because of the pull of ITB

Pivot shift is a term used to describe a specific sign which can be clinically demonstrated during physical examination. It is also used to characterize the typical description of the patient - a feeling of “going out” of their knee when they try to laterally pivot. [12]

The Pivot shift actually does not represent an instability event. On the contrary it is felt due to reduction of the already subluxated tibia on the femur. The Pivot Shift test is a useful test in diagnosing a clinically significant laxity [13] and a positive pivot shift test is regarded as one of the indications for Anterior Cruciate ligament reconstruction. Various studies have reported sensitivity ranging from 84%-98.4% of this test for diagnosing a ACL injury. The test's specificity ranges from 35% in alert patients to 98.4% in anesthetized patients. [14]

In an ACL deficient knee the tibia is anteriorly subluxated when the knee is extended. As the knee is flexed , the action of Iliotibial band changes in relation to the axis of the knee. At 30-40 degrees of knee flexion Iliotibial band ITB starts behaving as a knee flexor rather than a knee extensor. This change in tension in ITB pulls the subluxated tibial plateau posteriorly as the ITB is attached to anterior lateral tibial tubercle (Gerdy”s Tubercle). This reduction of tibia can be perceived as a sudden clunk or a positive Pivot shift sign. [15]

Technique: Patient lies in supine position with the hip in 30 degrees of abduction. The examiner stands at the foot end and hold the leg in slight Internal Rotation. With the other hand he holds the proximal & lateral leg. An axial load & Valgus force is applied as the leg is gently flexed from extended position. At about 30-40 degrees flexion the tibial subluxation reduces(positive test result).This reduction can be palpated and at times it is even audible.

Some authors have reported that external rotation of tibia can produce a greater pivot shift sign as compared to Internal rotation of tibia. However Pivot shift test done with tibia in external rotation needs to be differentiated from test for Postero lateral instability. If we repeat the test with tibia in Internal rotation the Pivot shift test would still be positive if the pivot shift is because ACL deficiency.

However if the Pivot shift test was positive with tibia in external rotation and negative when tibia is held in Internal rotation the Pivot shift was because of injury to PLC .

Similarly hip positioning also affects the grade of pivot shift. Bach et al reported that hip abduction and external rotation of tibia produces higher pivot shift grades when compared to hip being in adduction with tibia in either external or Internal rotation. [16] However false Pivot shift test can be seen in certain conditions like:

- Generalised ligamentous laxity.
- ITB rupture thus preventing the reduction of subluxated tibia.

- Medial instability prohibiting exertion of sufficient Valgus stress to elicit positive Pivot shift.
- Locked Bucket Handle tear preventing Pivot shift.

Posterior Instability

The PCL acts as the primary restraint to posterior translation of tibia on the femur. The PLC, LCL & MCL acts as secondary restraints against posterior translation.

PCL injury is not as common as ACL injury and mechanism of injury includes both low energy as well as high energy trauma producing a posteriorly directed force against a flexed knee. This can happen due to a fall on plantar flexed foot or because of a dashboard injury. Instability is the most common complaint although frequency of instability reported with PCL injury is less than that with ACL injury. PCL injury may occur in isolation but usually it is a part of multiligamentous injury with PLC involvement reported in upto 60% cases of PCL injury. [17]

The load bearing capacity, the tensile strength and size of the Anterolateral Bundle AL of the PCL is much more than that of Posteromedial bundle, and thus the biomechanical properties of PCL are mainly dependent on the integrity of the Anterolateral bundle. [18] Isolated sectioning of PCL results in increased posterior translation of tibia maximally demonstable at 90 degrees of knee flexion. Isolated injury to PCL has neither any effect on Internal or External rotation of tibia or on Varus or Valgus opening of the joint.

Posterior Drawer Test

Figure 6: Posterior drawer test. Positive drawer test result whether tibia is held in neutral or internal rotation is suggestive of PCL deficiency. Posterior drawer test negative when tibia is held in neutral rotation but positive when tibia is held in internal rotation is higly suggestive of PCL injury leading to PLRI

Technique: The patient lies supine on the table with hip flexed to 45 degrees , knee flexed to 90 degrees & the tibia in neutral rotation. The examiner can sit on the foot of the patient to keep the leg stabilized. Patient must be encouraged to relax his hamstrings. The normal relationship of tibial plateau being 1 cm anterior to femoral condyle should be ascertained. Once the patient is fully relaxed , grasp the upper tibia with both hands with index fingers palpating that hamstrings are relaxed thumbs over the anterior joint line. A posteriorly directed translation force is applied and the movement of the tibia along with quality of the end point is noted and graded compared to the contralateral leg.

The posterior drawer test has been reported to have a sensitivity of 90% and a specificity of 99% in diagnosing PCL injuries.[19] If the posterior drawer test is negative with tibia in both neutral as well as Internal rotation it virtually rules out PCL injury. However if the posterior drawer test is negative when the tibia is held in neutral rotation, but positive when tibia is internally rotated it is suggestive of PLC tears leading to Posterolateral rotatory instability PLRI .

Shelbourne et al [20] reported that quality of the end point is not very reliable for grading of PCL injuries as firm end point returns in about 2 weeks after PCL injuries due to other supporting structures being intact. They recommended that posterior translation of tibia should be considered more reliable while grading severity of PCL dysfunction.

Posterior Lachman Test

Although posterior tibial translation is best documented with knee flexion at 90 degrees, in an acutely injured knee it is sometimes impossible to comfortably bend the knee to 90 degrees.The Posterior Lachman test may be useful in such conditions.

Technique: Patient lies supine on the table with the knee in 30 degree flexion and tibia in neutral rotation. One hand of the examiner stabilizes the distal femur and with the other hand firm pressure is exerted on the anterior aspect of proximal tibia to induce backward translation. Abnormal backward translation of tibia is regarded as positive test result.

Increased backward tibial translation at both 30 & 90 degrees with maximum translation at 90 degrees is suggestive of PCL deficiency.

However increased backward translation at 30 degrees but not at 90 degrees is suggestive of PLC injury.

The Posterior Sag Test

The Posterior Sag test is a static test showing 100 % specificity and 79 % sensitivity for detecting PCL deficiency. [19]

Technique: Patient is placed supine with knees bent to 90 degrees & both feet comfortably resting flat on the examination table. The patient is asked to relax especially his quadriceps muscles. The patient is examined from the side. The test is said to be positive if anterior aspect of tibia is found to sag relative to anterior aspect of femoral condyles when compared with the normal contralateral knee.

The Active Quadriceps Test

This test involves using patient's own quadriceps contraction as the displacing force for abnormal tibial translation on the femoral condyle. The quadriceps neutral angle is defined as the angle of flexion of the knee (60-70 degrees) at which the vector of force generated by pull of the quadriceps is parallel to tibial shaft .At this angle if the quadriceps contracts and the foot is prevented from moving it only results in an increase in joint contact pressure.

Technique: The patient lies supine on the examination table & the knee is flexed to 90 degrees. It is essential that the flexion of knee should be more than the quadriceps neutral angle. As the angle of flexion of knee is more than the quadriceps neutral angle any contraction of quadriceps at this angle leads to a vector force which has an anterior drawer component in relation to tibial shaft. The patient is asked to gently slide his fixed foot forward resulting in reduction of posteriorly sagged tibia. The test result is considered positive for PCL deficiency if the tibia shifts anteriorly by more than 2 mm.

ROTATORY INSTABILITIES

Antero-Medial Rotatory Instability (AMRI)

AMRI results from excessive abduction, external rotation force on the knee leading to anterior subluxation of the medial tibial plateau relative to the medial femoral condyle. In normal knees Posteromedial corner PMC acts as primary restraint throughout the whole range of movement against anteromedial subluxation of tibia on the femur. Injury to superficial and deep MCL, or the PMC can lead to anteromedial rotatory instability. The PMC comprises of posterior horn of medial meniscus, the Posterior Oblique Ligament POL, meniscotibial ligaments, expansions of the semimembranosus and Oblique Popliteal Ligament.

AMRI is the most common type of knee instability.

AMRI in itself is also the most common cause of ACL disruption. However in initial stages AMRI shows minimal symptoms. With passage of time instability often progresses to anterolateral rotatory instability also & then AMRI combined with ALRI produces significant incapacitation .

Diagnosis: AMRI can be diagnosed by :

- Anterior Drawer Test with Tibia in External Rotation (Slocum Test).
- Pain at medial aspect of knee along with Increased medial joint opening with Valgus stress test at 30 degrees of flexion.
- Dial Test at 30 and 90 degrees (Prone External Rotation Test)

Dial Test at 30 and 90 degrees (Prone External Rotation Test)

Figure 7: Dial test at 30° and 90° of knee flexion. External rotation of the knee injured side more than 10° of the normal side both at 30° and 90° of knee flexion indicates combined PCL + PLC injury. External rotation more than 10° and 30° of flexion but less than 10° and 90° flexion indicates that PCL is intact and there is isolated PLC injury.

The patient lies prone on the examination table. The knees are flexed to 30 degrees. The examiner stands at the foot end of the table holding both the heels of the patient in his hands .A maximum external rotation force is applied and the angle between the thigh and the foot of the patient is noted on both the sides. A difference of 10 degrees or more between 2 sides is taken as positive Dial test.

The knees are then bent to 90 degrees and again a maximal external rotation force is applied to both legs and thigh foot angle is noted on both sides

While application of external rotation force the position of tibial condyle in relation to femoral condyle is also assessed along with measurement of the thigh foot angle. Anteromedial subluxation of medial tibial condyle in relation to femoral condyle along with difference of more than 10 degrees in measured external rotation is suggestive of AMRI. Posterolateral subluxation of lateral tibial condyle in relation to lateral femoral condyle is suggestive of PLRI.

If the measured external rotation is greater than 10 degrees at 30 degrees of knee flexion but lesser than 10 degrees at 90 degrees of knee flexion it is suggestive of an isolated PLC injury. An intact PCL restricts the external rotation at 90 degrees of flexion. However if measured external rotation is greater than 10 degrees at both 30 and 90 degrees of knee flexion it is suggestive of both PLC + PCL injury.

Antero-Lateral Rotatory Instability (ALRI)

An acute internal rotation and adduction stress on weight bearing knee results in Anterolateral instability. The anterolateral stabilizing structures have been described by many names in the literature including mid third lateral capsular ligament, Anterolateral ligament (ALL), Anterolateral capsule & the Anterolateral Complex. Apart from preventing anterior translation, ACL also prevents excessive internal rotation of tibia. ACL incompetence is essential for pathological internal rotation of tibia & sectioning of secondary Anterolateral stabilisers of knee in presence of an intact ACL did not produce significant internal rotation of tibia.

At 30 degrees of knee flexion the axis of internal rotation of knee is located on medial side of knee. In presence of Lateral Capsular injury, ACL & MCL acts as secondary stabilizers against Anterolateral rotational instability. Also the most clinically significant anterolateral tibial subluxation associated with ACL deficiency is also reported between 0-30 degrees of knee flexion. Claes et al reported that ACL provided most resistance to internal rotation of tibia at flexion angles less than 30 degrees. At flexion angles more than 30 degrees the fibres of ALL provided more resistance to internal rotation of tibia as compared to ACL. **[21]**

Diagnosis:

- Pivot Shift Test with Tibia in Internal rotation.
- Anterior Drawer test with Tibia in Neutral Rotation.
- Jerk Test of Hughston
- Losee test
- The Flexion Rotation Drawer Test

Jerk Test of Hughston

Figure 8: Jerl test of Hughston. With knee in 90° of flexion and tibia internal rotation a valgus force is applied at the knee and the knee is gradually extended. In presence of ALRI at about 30° of knee flexion, the tibia subluxates anteriorly giving a positive test result.

This test can be considered as opposite of Pivot shift test. The patient is placed supine on the table with hips in 45 degrees & the knee in 90 degrees of flexion. In one hand the examiner holds the tibia in internal rotation , and with the other hand he applies a valgus force at the knee. The knee is gently extended. At about 30 degrees of knee flexion the tibia can subluxate anteriorly & internally with a sudden jerk. This subluxation of tibia with a jerk is regarded as a positive test result. As we continue extending the limb the amount of subluxation will reduce but the anterior subluxation will continue to persist.

Sometimes a torn meniscus interposes between the tibia and femur and can give a false positive test result as the knee is moved from a position of flexion to extension.

Losee test:

The patient is placed supine on the table with knee in 45 degrees of flexion. In one hand the examiner holds the tibia in external rotation , and with the other hand he applies a valgus force at the knee. The knee is gently extended and the leg is allowed to drift into internal rotation . At about 20 degrees of knee flexion the tibia subluxates anterolaterally with a clunk. The clunk is perceived by the examiner whereas the patient perceives it as an episode of instability.

The Flexion Rotation Drawer Test

The patient lies comfortably in supine position. The examiner holds the tibia in neutral rotation in 15 degrees of knee flexion . In an ACL deficient knee this allows the femur to sag posteriorly as compared to tibia and externally rotate. Now hold the leg with the other hand and gently flex the knee. As the knee flexion reaches around 40 degrees of flexion the tibia reduces on the femur along with internal rotation of the femur. Gently flexing & extending the knee through range of motion the examiner can elicit the subluxation/reduction & rotation of the tibia and the femur.

Posterolateral Rotatory Instability (PLRI)

A posteriorly directed force taking the knee into hyperextension can cause disruption of posterolateral corner of the knee. The Posterolateral corner of the knee not only restrains the posterior translation of tibia (near full extension),but also the external rotation and varus rotation of tibia.The PLC is complex structure composed of the Lateral Collateral ligament, the arcuate ligament ,the fabellofibular ligament and the posterior capsule. The Iliotibial band ITB, popliteus & biceps tendon also provides dynamic stability to the PLC. Injury to arcuate ligament is mainly responsible for failure of PLC resulting in PLRI.

Identification of PLRI & its management is important as failure to address the posterolateral instability is one of the major causes of failure of ACL reconstruction surgery. [22] Many times due to varus associated with PLC injuries, patients with chronic PLC injury are mis diagnosed as a case of tibia vara & may undergo incorrect treatment by proximal tibial osteotomy.

A PLC injury results in increased posterior translation of tibia (esp near full extension), increased external rotation & increased varus instability particularly at 30 degrees of flexion.

Diagnosis:

- One must be careful in differentiating between isolated PLC injury, PCL injury or a combined injury. Both PCL as well as PLC injury results in abnormal posterior translation of tibia but in different degrees of knee flexion. Whereas isolated PCL injury will show maximum posterior translation of tibia at 90 degrees of flexion, isolated PLC injury will show maximum posterior translation around 30 degrees of knee flexion. Hughston et al [23] suggested that a negative posterior drawer test done with tibia in internal rotation can rule out PCL injury. On the other hand a positive posterior drawer test with tibia in internal rotation is suggestive of PLC injury.
- Pivot Shift Test: If Pivot Shift test is positive when the tibia is held in either external or Internal rotation it is suggestive of ACL injury. However If the Pivot shift test is positive with tibia in external rotation and negative when tibia is held in Internal rotation the Pivot shift is because of injury to PLC .
- Reverse Pivot Shift Test
- Dial test at 30° & 90°
- Posterolateral Drawer Test
- External Rotation Recurvatum Test

Reverse Pivot Shift Test

Figure 9: Reverse Pivot Shift Test. With knee at 90° of flexion and tibia in external rotation, a valgus force and axial load is apllied on the knee. The knee is gradually extended. In presence of PLRI, the tibia is subluxated at the start of the test. As the knee is gently extended at about 30° of knee flexion, the subluxated tibia reduces back (opposite of Pivot Shift test) due to pull of ITB.

Technique: Patient lies in supine position with the hip in 30 degrees of abduction. The examiner stands at the foot end and holds the proximal tibia in External Rotation & 90 degrees of knee flexion. A valgus stress is applied along with an axial load .The other hand supports the distal part of the leg. While applying the valgus stress & axial load while holding the knee in maximal external rotation the knee is gently extended.

In pts with PLRI the lateral tibia is subluxated at the start of the test. As the knee is gradually extended at about 30 degrees of flexion the lateral tibia reduces back on the femur with a palpable shift or jerk.This palpable shift or jerk is regarded as a positive Reverse Pivot shift test. As the knee is extended the pull of the iliotibial band ITB changes from a flexion to an extension vector, thereby reducing the tibia. Its known as reverse pivot shift because of change in pull of ITB from a flexion vector to an extension vector is reverse of what happens in a pivot shift test where on flexion the pull of ITB changes from an extension to a flexion vector.

Dial test at 30 & 90 degrees

On doing the dial test, posterolateral subluxation of lateral tibial plateau in relation to lateral femoral condyle is suggestive of PLRI.

If the measured external rotation is greater than 10 degrees, at 30 degrees of knee flexion but lesser than 10 degrees at 90 degrees of knee flexion it is suggestive of an isolated PLC injury. An intact PCL restricts the external rotation at 90 degrees of flexion.

On the other hand measured external rotation of more than 10 degrees at both 30 and 90 degrees of knee flexion is indicative of combined PLC and PCL injury. **[24],[25],[26]**

Posterolateral Drawer Test

Technique: The patient is placed in similar position in which we do a Reverse pivot shift test with the hip in 30-45 degrees of abduction , the knee in 90 degrees of flexion & the tibia in external rotation. The foot is fixed in this

position & the examiner places his hands on the anteromedial & anterolateral joint lines. A posterior drawer test is done .

Appreciation of the anterolateral tibia externally rotating relative to femoral condyle indicates a positive test result indicating PLC injury.

External Rotation Recurvatum Test

Hughston [27] described this test as the ultimate test for diagnosis of PLRI. The patient is placed supine on the table with knees in extension & both feet together. The examiner stands at the foot end of the patient grasps both the legs with great toe and lifts the legs off the table. In presence of PLC injury the knee falls into hyperextension, external rotation & varus.

Patellofemoral Instability

Anterior knee pain, one of the commonest Orthopedic problems can be a manifestation of patellofemoral joint instability. Other common symptoms of patellofemoral instability are, swelling,crepitus, difficulty in squatting, climbing or descending stairs or abnormal patellar gliding or slipping. Patellofemoral instability is usually multifactorial, like excessive Quadriceps angle (Q angle), patella alta, femoral trochlear dysplasia, excessive femoral anteversion, external tibial torsion, genu valgum & weakness of vastus medialis obliqus (VMO).

Recentely there has been a lot of focus on MPFL injury/tear being the chief contributor for traumatic patellar instability. Sallay et al [28] in a series of 19 pts with patellofemoral instability reported MRI evidence of MPFL tear in 87% patients. They further reported evidence of increased signal intensity near adductor tubercle in 96% patients & within VMO in 78% patients.

Shape of femoral condyles & patellar facets also contribute to patellofemoral stability. The anterior border of the lateral femoral condyle is 1 cm anterior to the anterior border of the medial femoral condyle. Similarly the lateral patellar facet is longer & has more acute slope as compared to medial patellar facet. Any anatomical variations in these features can cause patellofemoral instability.

Q Angle assessment

Technique: The patient lies supine with both legs parallel to each other. The tibial tuberosity is marked first. The patella is centred in the trochlear groove and centre of patella is marked. Next the examiner marks the anterior superior illiac spine (ASIS). The angle between the ASIS to the centre of reduced patella & tibial tuberosity to centre of reduced patella is measured with the help of a goniometer. The Q angle should also be measured in sitting position with knees flexed to 90 degrees.The Q angle generally measures about 15 degrees in females & 10 degrees in males. Any increase in Q angle increases laterally directed forces on patella leading to instability.

Patellar Tracking J Sign

Technique: During normal range of motion the patella smoothly engages the femoral trochlea in about 40 degrees of flexion. Any abrupt shift of the patella either in engagement of patella in the femoral groove on flexion or shift out of the trochlear groove on extension represents a J path of the patella relative to the trochlea. This is known as positive J sign.

The examiner simply observes the patellar motion as the patient extends his leg from 90 degrees of flexion. Any sudden or excessive lateral shift of patella is taken as positive J sign.

Manual Translation test

Carlson et al [29] reported that patella in either direction medial or lateral, should not displace more than one half the width of the patella. Other authors have divided the patellar width into quadrants. Lateral displacement upto 2 quadrants is considered normal. Lateral displacement of 3 quadrants is suggestive of incompetent medial restraint, whereas lateral displacement of 4 quadrants is indicative of a patella that can be dislocated.

Technique: The patient lies supine on the table with both knees fully extended.The examiner places both thumbs on the medial aspect of patella & slowly applies laterally directed force on patella. Patellar translation is measured and number of quadrants the patella translated is recorded.

Apprehension Test

Technique: Similar to Manual translation test the patient lies supine on the table with both knees fully extended. The examiner places both the thumbs on the medial aspect of patella & slowly applies laterally directed force on patella. The patients reaction is noted. The patient might become apprehensive& restless, may resist the lateral force being applied by tensing his quadriceps and may attempt to flex the knee. [30] Patients complaint of pain while the examiner applies laterally directed force is not taken as a positive test result. The patients apprehension and resistance to laterally directed force is only taken as a positive test result.

CONCLUSION

Rotatory instabilities are more difficult to assess and interpret. Their diagnosis requires an examiner to be skilled, systematic and detailed in his physical examination. Accurate diagnosis is the stepping stone on which pillars of successful treatment are built. It is of outmost importance to understand the contribution of anatomic structures to the stability of the knee. By being thorough in the anatomy of the knee esp the posteromedial and the posterolateral corner of the knee and taking into consideration the function of these structures an orthopedic surgeons ability to clinically diagnose patterns of knee injuries and various types of knee instabilities can be greatly enhanced.

Type of Instability	Structures injured	Diagnostic Tests
Varus Instability	Lateral compartment ligaments (LCL+ PLC) with PCL injury	- Varus stress test at 0 & 30 degrees of knee flexion
Valgus Instability	Medial compartment ligaments (MCL+ PMC) with PCLinjury	- Valgus stress test at 0 & 30 degrees of knee flexion
Anterior Instability	ACL & middle third of medial & lateral compartment ligaments (MCL & LCL)	- Anterior Drawer Test - Lachman Test
Posterior Instability	PCL & PLC injury	- Posterior Drawer Test
Anteromedial rotatory instability (AMRI)	Medial & Posteromedial compartment. Ligaments MCL+PMC and ACL injury	- Anterior Drawer with tibia in Ext Rotation. - Dial test at 30 & 90 degrees (Post Ext Rotation test)
Anterolateral rotatory instability (ALRI)	Mid-third lateral capsular ligament, Anterolateral ligament (ALL), and ACL injury	- Pivot Shift Test with Tibia in internal rotation - Anterior drawer test with tibia in neutral rotation - Jerk test of Hughston
Posterolateral Rotatory Instability (PLRI)	Injury to posterolateral complex (Arcuate Complex)	- Reverse pivot shift test - Posterolateral drawer test - External rotation recurvatum test

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