# The Pivot Shift

Clayton G. Lane, MD
Russell Warren, MD
Andrew D. Pearle, MD

## Abstract

The Lachman and the pivot shift are the two clinical tests most commonly used to assess instability in the anterior cruciate ligament (ACL)–deficient knee. Because it is quantifiable, the Lachman test has become the benchmark for assessing the success of ACL reconstruction. As a result, surgical techniques have been developed that effectively eliminate anterior laxity of the knee. Recent studies have shown, however, that rotational stability is not always restored after ACL reconstruction. Furthermore, there is mounting evidence that the pivot shift examination correlates with functional instability and patient outcomes better than does any other physical examination test. This test attempts to reproduce the functional combined rotary and translational instability in the ACL-deficient knee. Although the pathologic kinematics of the pivot shift are difficult to measure, recent technological advances have allowed more accurate and objective descriptions of the pivot shift, which have furthered our understanding of the complex motions involved. These advances may lead to a method of quantifying the pivot shift for research purposes and, ultimately, to ACL reconstruction that is tailored specifically to each patient's objectively measured rotational instability.

Perspectives on Modern Orthopaedics articles provide an objective appraisal of new or controversial techniques or areas of investigation in orthopaedic surgery.

Dr. Lane is Fellow, Sports Medicine and Shoulder Service, Hospital for Special Surgery, New York, NY. Dr. Warren is Attending Orthopaedic Surgeon, Sports Medicine and Shoulder Service, Hospital for Special Surgery. Dr. Pearle is Assistant Attending Orthopaedic Surgeon, Sports Medicine and Shoulder Service, Hospital for Special Surgery.

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Reprint requests: Dr. Lane, Alabama Orthopaedic Clinic, 3610 Springhill Memorial Drive North, Mobile, AL 36608; cgl@alortho.com.

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Clinical instability of the knee associated with anterior cruciate ligament (ACL) injury was first described by Amandee Bonnet in 1845.[1] In the early part of the 20th century, Hey Groves,[2] Robson,[3] and Jones and Smith[4] published case reports of the injury and descriptions of primary repair. Alwyn Smith[4] further described "external rotation of the tibia," indicating an appreciation of a rotational component to knee instability. Likewise, Palmer[5] in 1938 described a dynamic, circular rotation of the lateral condyle around the more constrained medial compartment during flexion in an ACL-insufficient knee.

The first published physical examination test for rotary instability of the knee is credited to Slocum and Larson.[6] This static test involves applying an anterior drawer force with and without external rotation of the leg. The test is positive when translation increases with 15° of external rotation of the leg. The authors reported that anteromedial instability caused by capsular injury was the predominant defect in the "slipping knee" and described the pes anserinus transfer as a means of controlling this instability. In contrast, Galway et al[7] believed that injury to the ACL was the primary cause of the functionally unstable knee and that anterolateral instability predominated. In 1972, these authors coined the term "pivot shift" and described the first derivation of a test that is used to this day. They also proposed a treatment technique for an extra-articular anterolateral stabilizing procedure using a strip of the iliotibial band (ITB).

In the past few decades, many studies have been published on pivot shift, most of them suggesting modifications of the original test (Table 1). The broad range of examination techniques resulted from disagreement concerning the pathologic motion that predominates and the soft-tissue injuries that are involved. For example, Hughston et al[9] in 1976 classified instabilities of the knee as anteromedial, anterolateral, or pos-

**Table 1**

**Examination Techniques for Pivot Shift***

| Study | Test | Technique | Proposed Pathomechanics |
|---|---|---|---|
| Galway and MacIntosh[8] | Lateral pivot shift | With the patient supine, lift the ankle with the right hand. Place the left hand over the fibular head to support the knee. Allow the leg to fully extend while internally rotating with the right hand to increase subluxation. Apply strong valgus force with the left hand and flex the knee. The clunk occurs at 30°. | Forward subluxation of the lateral tibial plateau occurs in extension and internal rotation; the medial plateau subluxates to a lesser degree. The subluxated lateral plateau impinges on the femur with valgus stress until 30°, when it suddenly reduces. |
| Slocum and Larson[6] | Slocum test | The patient lies on the left side with the left hip and knee flexed and in front of the right foot, which rests on the examination table. Rotate the pelvis 30° to 50° posteriorly until the weight of the leg is on the inner border of the right heel, and flex the right knee 10° so that a valgus force is provided by gravity. Palpate the anterolateral right tibia at the joint line with the right index finger, and place the right thumb over the fibula. The left hand is placed at the distal femur with the thumb behind the lateral condyle. Flex the knee slowly. The clunk occurs at 25° to 40°. | Same as above |
| Hughston et al[9] | Jerk test | With the patient supine, flex the right hip to 45° and the right knee to 90° while internally rotating the leg with the right hand. Apply a valgus stress with the left hand to the proximal tibia and extend slowly. The clunk occurs as 30° is passed. | Maximum subluxation of the lateral tibial plateau occurs at 30° and reduces on further extension. |
| Losee et al[10] | Losee modification | With the patient supine, cradle the right ankle near the examiner's side with the right hand. Hold the leg in external rotation. Place the left hand in the popliteal fossa and flex the knee to 30°. Move the left hand to the front of the knee with the palm down, with the fingers over the patella and the thumb behind the fibular head. Apply a valgus load with the left hand while bringing the knee into extension. The left thumb should push anteriorly on the fibula while the right hand allows the leg to internally rotate. The clunk occurs just short of full extension. | Initial external rotation keeps the tibia reduced while the knee is flexed. The clunk occurs when the tibia subluxates during extension. |
| Fetto and Marshall[11] | Pivot shift | With the patient 20° from supine on the left side, flex the right hip 20° and the right knee 70° by placing the left hand on the distal lateral thigh and the right hand around the ankle. Push down on the distal lateral thigh with the left hand to provide a valgus moment, and internally rotate the leg with the right hand as the knee is slowly brought into extension. The clunk occurs as the knee passes 20°. | The clunk occurs as the posterior horn of the lateral meniscus subluxates anteriorly beneath the femoral condyle near full extension (less distinct with lateral meniscectomy). |

* Techniques are described for examination of the right knee.

ITB = iliotibial band, MCL = medial collateral ligament, N/A = not applicable

**Table 1 (continued)**

**Examination Techniques for Pivot Shift***

| Study | Test | Technique | Proposed Pathomechanics |
|---|---|---|---|
| Tamea and Henning[12] | Pivot shift | Same as Galway and MacIntosh.[8] The clunk occurs between 20° and 40°. | From 0° to 20°, the tibia is subluxated anteriorly, resulting in an abnormal rolling motion. The clunk represents a sudden shift to sliding motion as the tibia reduces with flexion. |
| Losee[13] | Test for impinging reduction | With the patient supine, flex the knee to 20° while internally rotating the tibia with the right hand. While maintaining the 20° flexed position, apply a valgus load with the left hand and forcefully rotate the leg externally with the right hand. | As the knee is flexed, gravity rotates the lateral femoral condyle externally, subluxating the tibia. When the clinician externally rotates the leg, the tibia reduces. The test is positive even when the ITB is insufficient and the Galway and MacIntosh[8] lateral pivot shift test is negative. |
| Jakob et al[14] | Graded pivot shift | Same as Galway and MacIntosh.[8] However, the test should be repeated with the tibia in neutral rotation and external rotation. Grade I injury: clunk on internal rotation only; grade II injury: clunk with internal rotation and neutral; grade III injury: clunk with neutral and lateral rotation. | The degree of additional posterolateral or posteromedial soft-tissue injury determines the grade. |
| Bach et al[15] | Pivot shift | With the patient supine, cradle the foot with the right hand and place the left hand on the proximal lateral leg. The right hand controls rotation and the left controls flexion and valgus load. Repeat the test, varying the hip position and tibial rotation. Hip abduction of 30° with external rotation of the leg produces the highest-grade pivot shift. | The authors speculated that the ITB plays a predominant role in the clunk that occurs. |
| Matsumoto[16] | Pivot shift | Same as Galway and MacIntosh,[8] except avoid internal rotary torque. Clunk occurs between 20° and 40°. | Valgus load tenses the MCL, compressing the lateral compartment. As the knee is flexed, the tibia experiences an anterior force owing to the inclination of the lateral plateau, resulting in subluxation and internal rotation of the tibial plateau. As the knee is flexed further, the ITB supplies a posterior force to the tibia, which reduces it. A pronounced clunk occurs when there is more convexity of the lateral plateau; otherwise, the tibia slides. |
| Noyes et al[17] | Flexion rotation drawer | Same as Galway and MacIntosh,[8] except that the clinician should avoid internal rotary torque on the tibia and start at 15° to 20° of flexion. | N/A |
| Bull et al[18] | Pivot shift | Flex and extend the knee while holding the foot in internal rotation, external rotation, and neutral. | Degree of rotation and translation varies between patients. |
| Kubo[19] | Pivot shift | Flex and extend the knee with valgus force and no control of rotation. | N/A |

* Techniques are described for examination of the right knee.

ITB = iliotibial band, MCL = medial collateral ligament, N/A = not applicable

**Table 2**

**Effect of Soft-tissue Characteristics on Pivot Shift Examination in the ACL-deficient Knee**

| Soft-tissue Factors | Effect on Pivot Shift | Mechanism |
|---|---|---|
| ITB tightness | Decreases | Restricts subluxation |
| ITB looseness | Decreases | Allows internal rotation throughout range of motion so that there is no shift |
| MCL laxity | Decreases | Limits compression of lateral compartment with valgus stress |
| PLC | Increases | Increases external rotation |
| Medial meniscectomy | Increases | Increases anterior translation |
| Bucket-handle meniscus tear | Decreases | Blocks extension |
| Flexion contracture | Decreases | Prevents extension |

ITB = iliotibial band, MCL = medial collateral ligament, PLC = posterolateral corner

terolateral, and described the jerk test for eliciting anterolateral instability. They proposed that these instabilities were caused by capsular ligaments "but may be accentuated by a tear of the anterior cruciate ligament." In 1979, Fetto and Marshall[11] demonstrated that ACL injury is the essential element that causes the pivot shift. Isolated ACL sectioning in 25 cadaveric specimens produced anterior tibial translation and internal rotation, whereas sectioning of the ITB, lateral collateral ligament, or popliteus tendon did not.[12] Soon after, ACL reconstruction, which had been first proposed by Palmer,[5] was popularized by Clancy et al[20] as a means of treating rotational instability.

## Sensitivity, Specificity, and Reproducibility

It would seem that with the emergence of modern sports medicine and ACL reconstructive surgery, the pivot shift test would become the benchmark for measuring the success of surgical treatments. Instead, the Lachman test for uniplanar anterior translation remains the standard. The Lachman test, named after John W. Lachman of Temple University, is performed with the patient in a supine position. One hand of the examiner firmly grasps the distal femur, stabilizing it throughout the examination. The opposite hand grasps the proximal tibia with the thumb on the anterior joint line and the fingers wrapped around posteriorly. With the knee in 15° of flexion and slight external rotation, the tibia is pulled forward. The examiner assesses the amount of translation at the joint line by palpating with the thumb. Anterior translation with a "mushy" end point was considered a positive test by the original authors.[21] Subsequent authors have provided a grading scheme based on the degree of translation and presence or absence of an end point.[22]

One of the difficulties in assessing the importance of the pivot shift in knee instability is the broad range of examination techniques employed by various surgeons (Table 1). Another concern is the subjective nature of the pivot shift examination. Grading relies on the examiner's perception of the change of motion that occurs during this complex maneuver. The pathologic motion elicited is graded as a glide (grade I), clunk (grade II), or gross clunk with locking (grade III). A normal finding is graded as zero.[15] However, some patients, in the absence of trauma, have a physiologic, bilateral pivot of grade I or, rarely, grade II, because of joint laxity. The increased physiologic rotational laxity may increase the grade of pivot shift noted with ACL injury. In the absence of ACL injury and if the opposite extremity is not examined for comparison, the examiner may misinterpret this physiologic laxity as pathologic.

Not only is the grading subjective, but the forces applied during the maneuver are subject to variation among examiners. Even when the same technique is used, subtle changes in the magnitude of valgus force applied, hip position, and rotation of the leg have all been shown to affect grading.[15,23] Noyes et al[17] documented drastically different rotation and translation values in examinations of a single knee done by 10 different examiners. In contrast, the Lachman test is a simple maneuver that can be objectively measured using the KT-1000 (MEDmetric, San Diego, CA) or other instruments.[24]

A third confounding variable is the coexistence of other soft-tissue injuries in ACL-deficient knees, which makes interpretation of the grade of pivot shift more difficult (Table 2). Biomechanical studies have yielded valuable information regarding the contribution of other soft-tissue structures, both intact and injured, to pivot shift. In describing a modified pivot shift test, Slocum et al[25] contended that the ITB plays a role in the reduction of the tibia as its pull moves posterior to the axis of flexion. Many authors have agreed with this premise on a theoretical basis, and it was further bolstered by objective sectioning studies done by Losee.[13] In 1990, Matsumoto[16] performed biomechanical testing on 29 cadaveric knees and identified ACL injury as the essential component of pivot shift.

Sectioning of the ITB in the ACL-deficient knee diminished pivot shift but not internal rotation, and sectioning of the medial collateral ligament in the ACL-deficient knee diminished both pivot shift and the degree of internal rotation. Fewer than half of the ACL-deficient knees had a positive pivot shift, but all of the ACL-deficient knees had increased internal rotation. This may represent the effect of bone geometry on pivot shift.[16] Earlier cadaveric work by Fetto and Marshall[11] indicated that posterolateral corner injury may accentuate pivot shift, and other investigators have theorized that posterolateral corner or posteromedial corner injury must be present to elicit a grade III pivot shift.[14]

Finally, patient tolerance of the pivot-shift examination is poor, and patient guarding may limit the reliability of the test. Of 37 patients with isolated ACL tears, Donaldson et al[22] found that only 27% had a positive pivot shift examination on admission, whereas all 37 were positive with examination under anesthesia. However, in the same set of patients, the Lachman test was positive in 98% without anesthesia and in 100% with anesthesia. This issue may be more pertinent in modern orthopaedic practices, in which ACLs are often reconstructed within 6 weeks of injury, than it was in the early days of pivot shift testing, when chronic ACL laxity was more prevalent. In their recent meta-analysis, Benjaminse et al[26] found the specificity of the pivot shift test to be high whether the ACL insufficiency was acute or chronic and whether it was performed with or without anesthesia (specificity, 97% to 100%). However, in the absence of anesthesia, the sensitivity of the pivot shift test was relatively low for both acute and chronic ACL tears (sensitivity, 32% and 40%, respectively) compared with the sensitivity under anesthesia (sensitivity, 85% and 89%, respectively). In contrast, the sensitivity of the Lachman test was 94% to 98% in all scenarios.[26]

## Implications of a Positive Test

Although the limitations of the pivot shift test prevent it from being used as the primary measure of stability for research, it remains valuable for other reasons, such as its high specificity.[26] Perhaps more important, research has shown that the grade of pivot shift correlates closely with patient outcomes, while the Lachman test does not. In a study of 52 ACL repairs, Kaplan et al[27] established a direct correlation between assignment of a pivot shift grade on initial examination and return to sports. Kocher et al,[28] in a larger study of 202 patients, confirmed this correlation between pivot shift grading and sports participation and also found correlations between pivot shift grade and patient satisfaction and relief of symptoms. Neither instrumented laxity examination nor Lachman testing correlated with any of these variables. Leitze et al[29] reported 9-year follow-up on 87 patients who had undergone anterolateral stabilizing procedures. A positive pivot shift test after surgery correlated with patient dissatisfaction and decreased outcome scores. Lachman testing did not correlate with these variables, and neither Lachman nor pivot shift testing correlated with radiographic evidence of arthritis.

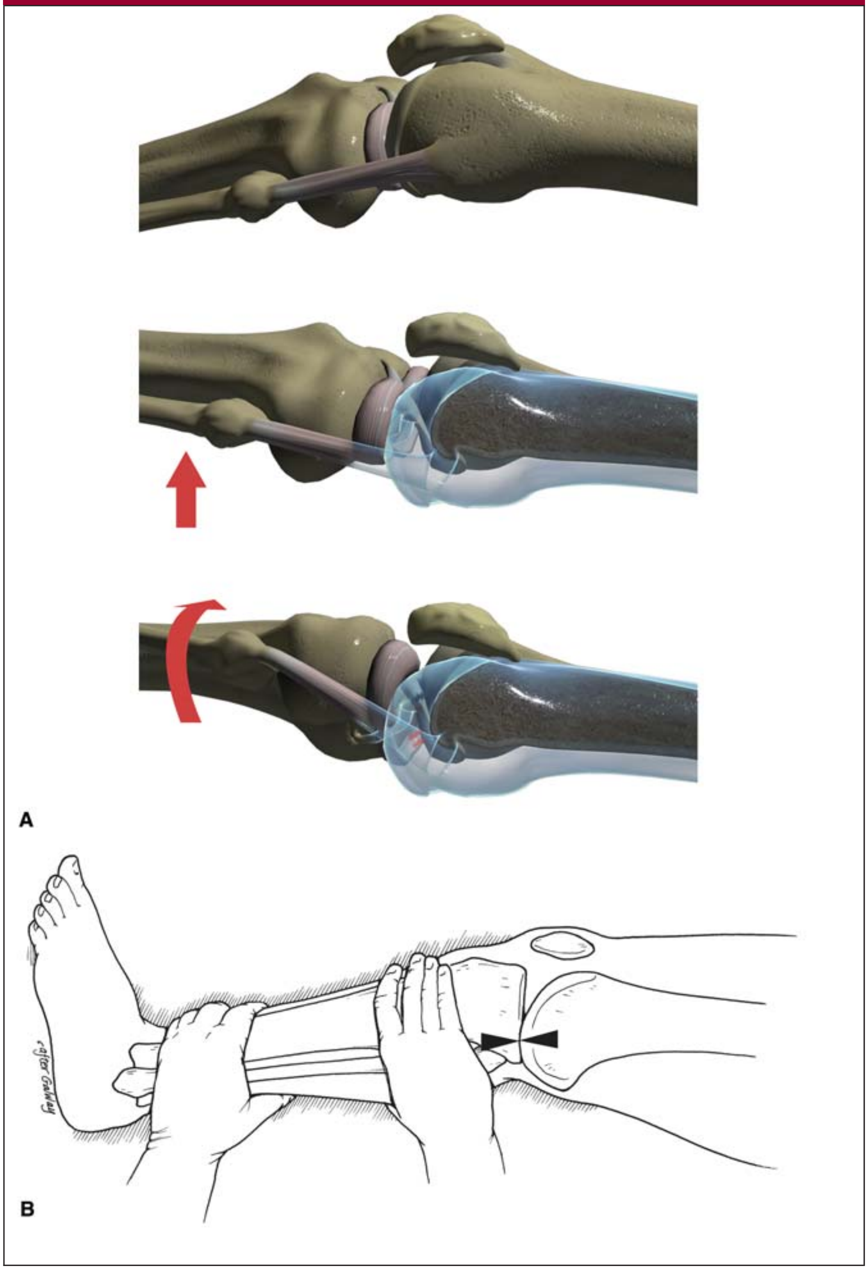
Other studies have suggested that patients with rotational instability are more prone to osteoarthrosis than are those without it. Bone scans of patients with positive pivot shift tests after ACL reconstruction demonstrate increased uptake at 5-year follow-up compared with those with no pivot shift.[30] Conteduca et al[31] found a trend toward increasing degree of chondromalacia with increasing grade of jerk test in 500 patients undergoing surgery for instability.

## Rotational Kinematics After ACL Reconstruction

The use of anterior translation measurements as the primary means to assess the outcome of ACL surgery may have led to procedures that effectively eliminate anterior laxity without consistently addressing rotational instability. Multiple biomechanical and clinical studies indicate that current surgical procedures to manage ACL deficiency may not restore rotational stability. In one study comparing two ACL reconstruction techniques, the incidence of grade I pivot shift after reconstruction was 16% in each group.[32] Similarly, Woo et al[33] found that after hamstring and patellar tendon reconstructions in cadaveric knees, anterior tibial translation was restored when an anterior load was applied. However, the grafts were not as effective at restoring anterior stability when a combined valgus and internal tibial torque was applied. Georgoulis et al[34] used a six-camera optoelectronic system to measure tibial movement during a high-demand pivoting activity following ACL reconstruction, comparing the repaired knee with the contralateral native knee and with age-matched controls. The reconstructed knee demonstrated a greater amount of internal rotation than did the contralateral native or control knees despite complete restoration of anterior translation on KT-1000 testing. At the same institution, it was also noted that reconstructed knees tend to have increased external rotation in the swing phase of gate.[35] Functional testing has also been done by Tashman et al,[36] using a stereoradiographic system to record kinetics while the patient runs on a decline treadmill after ACL reconstruction. This study also revealed an increase in external rotation in ACL-reconstructed knees; anterior translation was not different from that in the uninjured extremity.

The abnormal rotational kinematics reported in these and other stud-

**Figure 1**




**A,** Illustration of tibial subluxation. *Top*, Normal flexion. *Middle*, Normal extension. *Bottom*, Anterior tibial translation and rotation in an ACL-deficient knee. The arrow indicates the increased rotational instability. **B,** Lateral compartment impingement (arrowheads) as described by Galway and MacIntosh.[8] (Panel A courtesy of the Hospital for Special Surgery, New York, NY.)

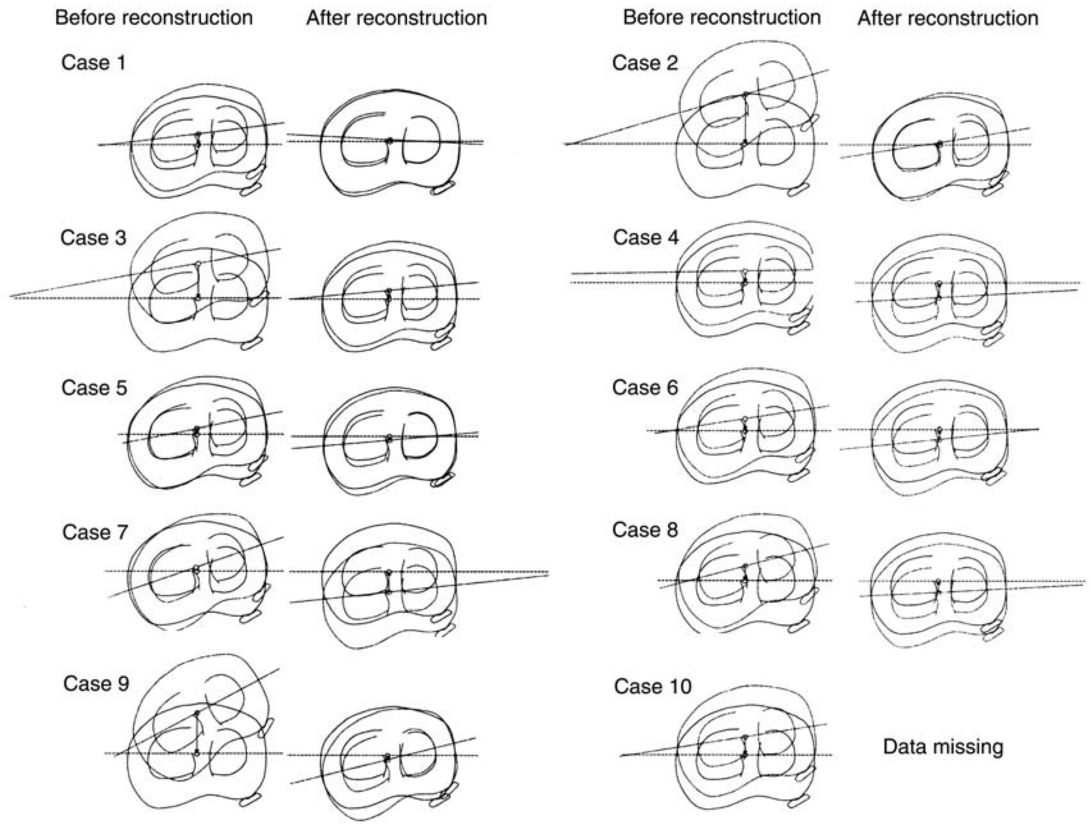
ies are the primary rationale for pursuing alternative procedures for ACL reconstruction. The most widely accepted technique for ACL reconstruction employs transtibial reaming of the femoral tunnel. This technique sometimes makes it difficult to place the femoral tunnel in the anatomic footprint of the native ACL on the wall of the lateral condyle.[37-39] The resulting vertical graft may control anterior translation without affecting internal rotation, such that the pivot shift is still present postoperatively.[40-43] Our practice is to ream the femoral tunnel through an anteromedial portal or to use a two-incision technique when patient anatomy limits femoral tunnel placement. Another approach, the double-bundle technique, is reported to better control complex multiplanar instability patterns in ACL-deficient knees.[44] Although clinical studies have, to date, failed to demonstrate objective differences between single- and double-bundle strategies, recreation of functional bundles of the ACL may result in more consistent elimination of the pivot shift.

## Pathologic Motions of the Pivot Shift

Although much effort has been expended to determine the exact pathologic motions that occur with pivot shift, the complex motions have proved difficult to analyze. Galway and MacIntosh[8] theorized that with the knee in full extension and an internal rotary torque applied to the leg, the tibial plateau subluxates anteriorly, the lateral side more so than the medial (Figure 1, A). When a valgus load is applied to the knee, the lateral plateau impinges on the lateral condyle, providing resistance to flexion (Figure 1, B). As the knee is forcibly flexed, this resistance is overcome, and the tibia slides posteriorly into a reduced position, causing a glide or a clunk, depending on the degree of subluxation.

Subsequent reports have borne out this theory. Tamea and Henning[12] demonstrated objectively that anterior tibial subluxation reduces with flexion. These investigators took serial radiographs while performing the pivot shift as described by Galway and MacIntosh.[8] They reported that the instant center of rotation of the knee shifts from an abnormally anterior position at 0° to 20° of flexion to abnormally posterior and proximal at 20° to 40°, and then to a normal position at 40° to 90° of flexion, the middle portion being the shift phase.[11]

**Figure 2**




Variable translation and rotation in patients with positive pivot shift. (Reproduced with permission from Bull AM, Earnshaw PH, Smith A, Katchburian MV, Hassan AN, Amis AA: Intraoperative measurement of knee kinematics in reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br* 2002;84:1075-1081.)

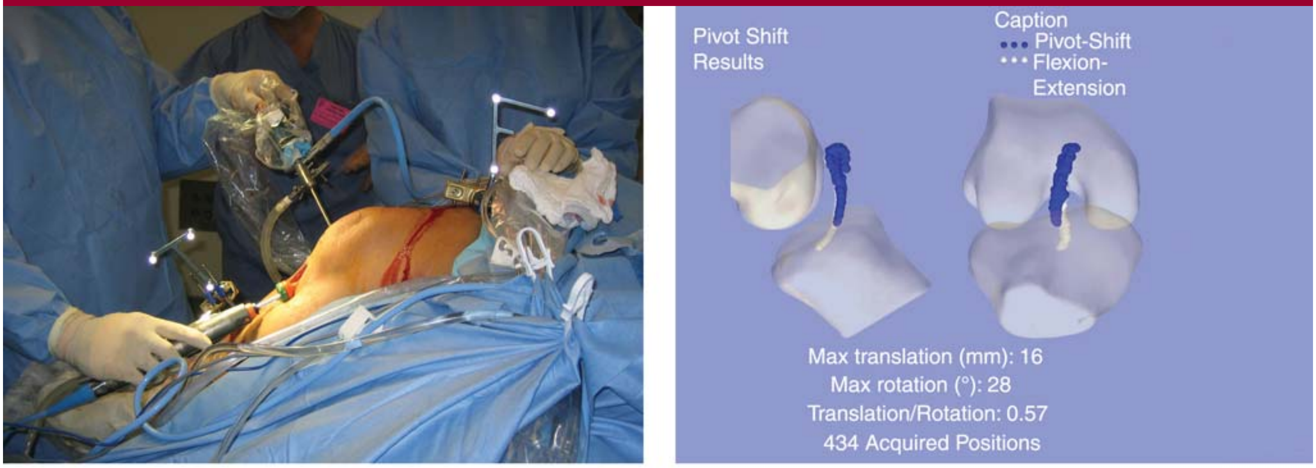
A biomechanical study in 15 cadaveric knees by Reuben et al[45] supported the premise that anterior translation is the predominant pathologic motion, but the authors added that this translation is accentuated by internal rotation of the leg. They also mentioned a secondary component of anterior translation of the medial compartment in some knees, one that may be accentuated with external rotation. Bull et al[18] demonstrated a subset of patients with such slightly different knee pathomechanics objectively, using the electromagnetic "flock of birds" device in the clinical setting (Figure 2). The investigators employed varying techniques of pivot shift examination, with the leg in internal rotation, external rotation, and neutral. In 8 of 10 patients with ACL injury, there was combined anterior tibial translation and rotation about an axis medial to the knee; in 1, the motion was predominantly rotary with the axis in the center of the knee; and in 1, the predominant motion was translation. This variability in pathologic motion in ACL-deficient knees could be the result of the degree of injury to the ACL, the patients' unique articular anatomy, or the contribution of unrecognized additional soft-tissue injury.

## Quantifying the Pivot Shift With Current Techniques

The biomechanical studies focusing on the pivot shift have employed a wide range of techniques, including cadaveric sectioning, serial radiographs, cable linear displacement transducers, electrogoniometers, and robotic arm manipulators with load cells, all of which have been used to attempt to quantify the motions involved.[12,16,19,33,35,46] The emergence of computer navigation in orthopaedics provides a new tool to analyze these complex motions.[47]

Hoshino et al[48] used electromagnetic navigation in a study correlating acceleration of posterior tibial translation during pivot shift testing with clinical grade. Skin sensors placed on the patient's thigh and leg provided six-degrees-of-freedom motion analysis as the limb was moved through an electromagnetic field during examination. The investigators

**Figure 3**




**A** **B**

**A,** Intraoperative photograph demonstrating rigid bodies with reflective markers in place during arthroscopy. **B,** Intraoperative measurement of kinetics during pivot shift testing. *Left*, Lateral view of the femur with the tibia moving freely. *Right*, Axial view of the femur with the tibia moving freely. (Courtesy of Hospital for Special Surgery, New York, NY.)

compared ACL-injured and contralateral knees of patients undergoing surgery under anesthesia. They found a correlation between both coupled anterior tibial translation and posterior tibial acceleration with clinical grade. However, there was no correlation between coupled anterior tibial translation measured in the pivot shift test and the anterior translation measured by the KT-1000. This suggests that the KT-1000 may not be the best clinical tool for measuring rotational instability.

The advantage of electromagnetic skin sensors is that they are noninvasive and easy to apply. However, these skin sensors are confirmed to be less accurate for taking measurements in the moving knee than are rigid body markers fixed to bone. The most current surgical navigation systems are infrared optical systems that employ rigid body markers. The software and techniques have evolved to a point at which these systems can recreate precise models of patient anatomy and guide surgical instrument placement in addition to recording movement during physical examination (Figure 3). This yields a realm of possibilities with the potential to individualize ACL reconstruction technique to each patient.

We believe that precise measurement of the kinematic components of the pivot shift will provide the foundation for this individualized approach. Using an optical navigation system, we recently correlated several components of the pivot shift examination with clinical grade.[49] Although coupled anterior tibial translation, acceleration of posterior translation, and maximal rotation all correlated with pivot grade, the newly described "angle of P" correlated the most strongly. This angle of P is based on the motion of the tibia in the sagittal plane during pivot shift testing and reflects coupled anterior translation (ie, combined internal rotation and anterior translation) and rate of reduction. The significance of this work and that of Hoshino et al[48] is that reproducible, objective measurement of the pivot shift in the clinical setting is now possible.

## Authors' Preferred Technique

To perform a pivot shift examination, it is important to abduct the hip to relax the ITB and allow the tibia to rotate. A valgus force on the proximal tibia is required to elicit a jump as the tibia subluxates anteriorly. We prefer to do this from a position of flexion to extension, noting the shift as the knee is extended, although it can be done in the reverse manner. Grasping the ankle of the right leg with the right hand, the examiner places the left hand proximally on the tibia, creating a valgus force. The tibia is started in external rotation, allowing it to rotate internally as the knee is extended. A jump is noted at approximately 10° to 20° of flexion. The finding can be graded from 0 to III, with III representing a locking in the subluxated position and II, a distinct jump. Grade I indicates a subtle change of motion or glide without an appreciated jump.

Patients requiring an ACL reconstruction will report instability as a chief complaint associated with athletic activities of jumping, cutting, and stopping quickly. Patients may use their hands to indicate joint movement while describing this instability, a motion we call the "two-fist sign." The patient with this complaint will generally have an ACL-deficient knee with a positive pivot shift, usually of grade II or III. Some patients are apprehensive about this test and will prevent the tibia from subluxating during the examination. Others, if asked, will note that the pivot shift or jump is what they feel happen to the knee when it gives out. If the knee has a full range of motion, the test when performed under anesthesia will always be positive for chronic ACL deficiency. Acute cases will usually be positive, but swelling, medial collateral ligament injury, or lack of extension may prevent the subluxation (Table 2).

Our preferred surgical reconstruction technique is a single-bundle ACL reconstruction with the graft placed, on a right knee, at about the 9:30 to 10 o'clock position. This allows the femoral attachment point to overlap the insertion sites of the anterolateral and posteromedial bundles following insertion and fixation of the graft.

## Summary

ACL injury is the essential pathologic factor of the pivot shift phenomenon. Factors that can enhance or mask the degree of shift in an affected knee include individual variations in laxity of the native knee and its articular geometry, examination technique, degree of patient guarding, and presence of associated soft-tissue injury. Our preferred examination technique is a subluxation maneuver most closely resembling the Losee modification. The predominant pathologic motion of the pivot shift is coupled internal rotation and anterior tibial translation, which will be elicited by this technique. Very different motions occur in a subset of patients, and alternative examination methods may be helpful. A reproducible, objective measurement of pivot shift using navigation or other means would represent an advancement in ACL research. This type of analysis may also help elucidate subtle variations in ACL instability kinematics among patients. Distinguishing these variations could allow for more targeted and individualized surgical reconstruction strategies. ACL reconstruction tailored to an individual's unique anatomy and pathologic kinematics should be the ultimate goal.

## Acknowledgment

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*Evidence-based Medicine:* References 26, 29, 34, 36, 41, and 43 are prospective, randomized level II studies. The remaining studies are level III (references 11, 12, 15-19, 22-24, 30-33, 35, 37-40, 42, 48, and 49) and level IV (references 5-9, 14, 20, 27, 28, 44, 45, and 47) case-control and cohort studies, or are level V expert opinion or miscellaneous studies.

Citation numbers printed in **bold type** indicate references published within the past 5 years.


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