Posterolateral Rotatory Instability of the Elbow: Part II. Supplementary Examination and Dynamic Imaging Techniques

Christopher L. Camp, M.D., Jay Smith, M.D., and Shawn W. O'Driscoll, M.D., Ph.D.

Abstract: Currently, a number of examination and imaging techniques exist for diagnosing posterolateral rotatory instability of the elbow. Although the posterolateral rotatory drawer is the primary examination maneuver, other special tests include the lateral pivot-shift test, prone push-up test, chair push-up test, and tabletop push-up test. In addition, posterolateral rotatory instability can be evaluated using radiography, magnetic resonance imaging, dynamic fluoroscopy, or dynamic ultrasound. In this Technical Note, each of these tests is described in detail. Video instruction is also provided to further explain the techniques and provide examples of positive tests.

Posterolateral rotatory instability (PLRI) occurs when the proximal ulna and radial head subluxate as a unit off the humerus in a rotatory fashion.[1] PLRI may present after trauma, lateral-sided elbow surgery, and severe cases of lateral epicondylitis (typically after corticosteroid injections), or manifest late in patients with cubitus varus.[1,2] Patients with PLRI typically experience a sensation of instability and/or mechanical symptoms that may be painful. When considering a diagnosis of PLRI, the patient's history and mechanism of injury are critical to consider. The primary diagnostic examination maneuver used to identify PLRI is the posterolateral rotatory drawer test, which is described in detail in Part I of this Technical Note.[3] This is the most sensitive examination maneuver and can reliably be performed in both the awake and anesthetized patient. To further supplement the physical examination, a number of additional tests have been described. These include the lateral pivot-shift test,[1] lateral pivot-shift apprehension test,[1] prone push-up test,[4] chair push-up test,[4] and the tabletop relocation test.[5] Each of these maneuvers has its own merits and limitations (Table 1). For instance, the lateral pivot-shift test can be difficult to perform in the awake patient due to inadequate relaxation or discomfort; however, when present, it is highly specific for PLRI. The various push-up tests have the advantage of allowing the patient to perform the maneuvers under their own volition; however, they may be less sensitive, fail to adequately quantify the degree of instability, and cannot be performed on the anesthetized patient.

In addition to these examination techniques, imaging can aid in the diagnosis of PLRI. Although static radiographs are generally negative, posterolateral subluxation of the radial head or ulnohumeral widening can occasionally be detected. Magnetic resonance imaging may reveal disruption in the lateral collateral ligament complex or joint incongruity if present. Computed tomography (CT) scans with 3D and 2D reconstructions reveal articular deformities such as dysplasia involving the coronoid, radial head, or trochlea. It also permits assessment of malunion and nonunion of fractures as well as impaction injuries (typically of the capitellum). Dynamic fluoroscopy and ultrasound are 2 additional modalities that can be helpful in making the diagnosis of PLRI.[6] Both can show instability by imaging the joint as a posterolateral rotatory stress is applied to the elbow. The purpose of this Technical Note is to highlight the value of these examination and imaging techniques. Furthermore, each test is described in detail and video demonstration

From the Department of Orthopedic Surgery and the Sports Medicine Center (C.L.C., S.W.O.); and Department of Physical Medicine and Rehabilitation and the Sports Medicine Center (J.S.), Mayo Clinic, College of Medicine, Rochester, Minnesota, U.S.A.

The authors report the following potential conflicts of interest or sources of funding: J.S. receives support from Sonex Health and Tenex Health. S.W.O. receives support from Tornier, Acumed LLC, and Aircast.

Received July 21, 2016; accepted October 12, 2016.

Address correspondence to Christopher L. Camp, M.D., Department of Orthopedic Surgery and the Sports Medicine Center, Mayo Clinic, College of Medicine, 200 First St., SW, Rochester, MN 55905, U.S.A. E-mail: camp.christopher@mayo.edu

2212-6287/16698/$36.00

http://dx.doi.org/10.1016/j.eats.2016.10.012

Table 1. Summary of Tests for Posterolateral Rotatory Instability of the Elbow Highlighting the Strengths and Weakness of Each

	Advantages	Limitations
Posterolateral rotatory drawer test	Most sensitive examination maneuver Allows assessment of degree of instability Can be performed in the awake and anesthetized patient Does not cause pain or discomfort for the patient	Not always performed or described accurately
Lateral pivot-shift test	Highly specific test Dramatic phenomenon when positive	May cause discomfort in some patients Can be difficult to perform in the awake patient if not able to relax
Push-up tests	Allows the patient to control the speed and force of the examination	Can only be performed in the awake and cooperative patient Does not assess the degree of instability
Radiograph	Evaluates bony structure and alignment	Generally unrevealing
Computed tomography scan	Shows articular dysplasia, malunion and nonunion of fractures, impaction fractures	Additional radiation
Magnetic resonance imaging	Allows assessment of the lateral collateral ligament complex Allows assessment of articular surfaces	Can miss lateral collateral ligament injuries Does not permit dynamic assessment
Dynamic fluoroscopy	Allows assessment of the degree of instability Can be performed in the awake and anesthetized patient	Radiation exposure for the patient and provider
Dynamic ultrasound	Allows assessment of the degree of instability Can be performed in the awake and anesthetized patient No radiation exposure	Emerging technology in need of additional validation

is provided for added clarity (Video 1). A thorough understanding of the posterolateral rotatory drawer test and these supplementary techniques will provide practitioners with the full armamentarium of tools with which to diagnose PLRI.

Evaluation Techniques

General

The patient history should focus on symptoms and, if applicable, the mechanism of injury. It is important to inquire about prior lateral elbow surgery and inspect the lateral side of the elbow for incisions. It is critical to discuss remote injuries to the elbow that may have occurred as a child, particularly in the setting of cubitus varus.[2] Dislocations or recurrent dislocations that began before skeletal maturity should be assessed for CT evidence of dysplasia. Patients complaining of instability or clicking are occasionally able to reproduce the subluxation themselves. The elbow should be assessed for alignment, range of motion, strength, and neurovascular status. Special tests to be considered include the posterolateral rotatory drawer test[3] (discussed in Part I), lateral pivot-shift test (also called the PLRI test),[1] lateral pivot-shift apprehension test,[1] tabletop relocation test,[5] chair push-up test,[4] and prone push-up test.[4]

Lateral Pivot-Shift Test

The lateral pivot-shift test, also referred to as the PLRI test, was the first test described to diagnose PLRI of the elbow.[1] It is performed with the patient lying supine on an examination table and the examiner standing behind the head of the table near the patient's head, as with the posterolateral rotatory drawer test. The patient's arm is lifted overhead and held securely by the examiner. Commencing with the elbow in full extension, a gentle supination torque is applied to the forearm by rotating the wrist. While slowly flexing the elbow, the supination torque is progressively increased while a valgus torque at the elbow and an axial load

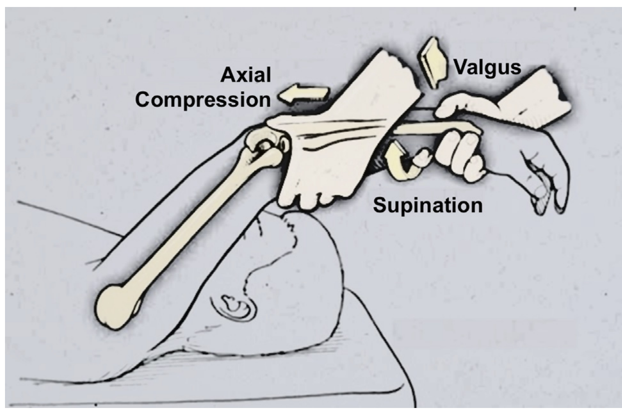

Fig 1. To perform the lateral pivot-shift test, as shown on the left elbow of the patient in the supine position, the arm is held securely by the examiner over the patient's head. The arm is moved from an extended to a flexed position, while the forearm is supinated and axial compression and a valgus load are applied to the elbow. As the subluxation increases, the supination torque is reduced while increasing the valgus torque. The pivot shift tends to occur between 20° and 40° of flexion, but it should be assessed at multiple angles.

along the forearm are added (Fig 1). In the range of 20° to 40° of elbow flexion (depending on the patient and degree of disruption of ligamentous and bony constraints), the supination torque is diminished and the valgus torque increased until the point of maximum subluxation (usually around 40°), at which time only a pure valgus torque is maintained. A positive examination is confirmed by witnessing subluxation of the radial head (a prominent bump on the posterolateral elbow), and dimpling of the skin behind the radial head that occurs as the posterolateral capsule is pulled into the joint. With further flexion, the elbow reduces with a visible and palpable clunk. It is important to relax the supination torque for reduction to occur without damaging the elbow. With practice, it is possible to alternately flex and extend the elbow back and forth through a small range, causing the elbow to subluxate and reduce. This examination is analogous to the lateral pivot-shift test of the knee, conceived by David L. MacIntosh, to diagnose knee instability caused by anterior cruciate ligament disruption.[7]

Although the visual and tactile feedback from a positive lateral pivot-shift test are more dramatic than for any other test, it is less reliable overall than the posterolateral rotatory drawer test for 3 reasons. First, it is somewhat complex to master, because it requires a continuous adjustment of forces and torques about the elbow while flexing the elbow. Second, it usually causes discomfort or apprehension in the awake patient, making relaxation difficult. As a result, it is typically easier to perform in the anesthetized patient. Finally, false negative tests occur because it is insufficiently sensitive to detect minor degrees of instability seen, for example, in patients with lateral epicondylitis (tennis elbow).

Lateral Pivot-Shift Apprehension Test

The lateral pivot-shift apprehension test is performed in the same way as the lateral pivot-shift test itself. The only difference is that a positive response is indicated by the patient's apprehension rather than a mechanical subluxation and reduction, just as with apprehension testing for anterior shoulder instability. The patient may

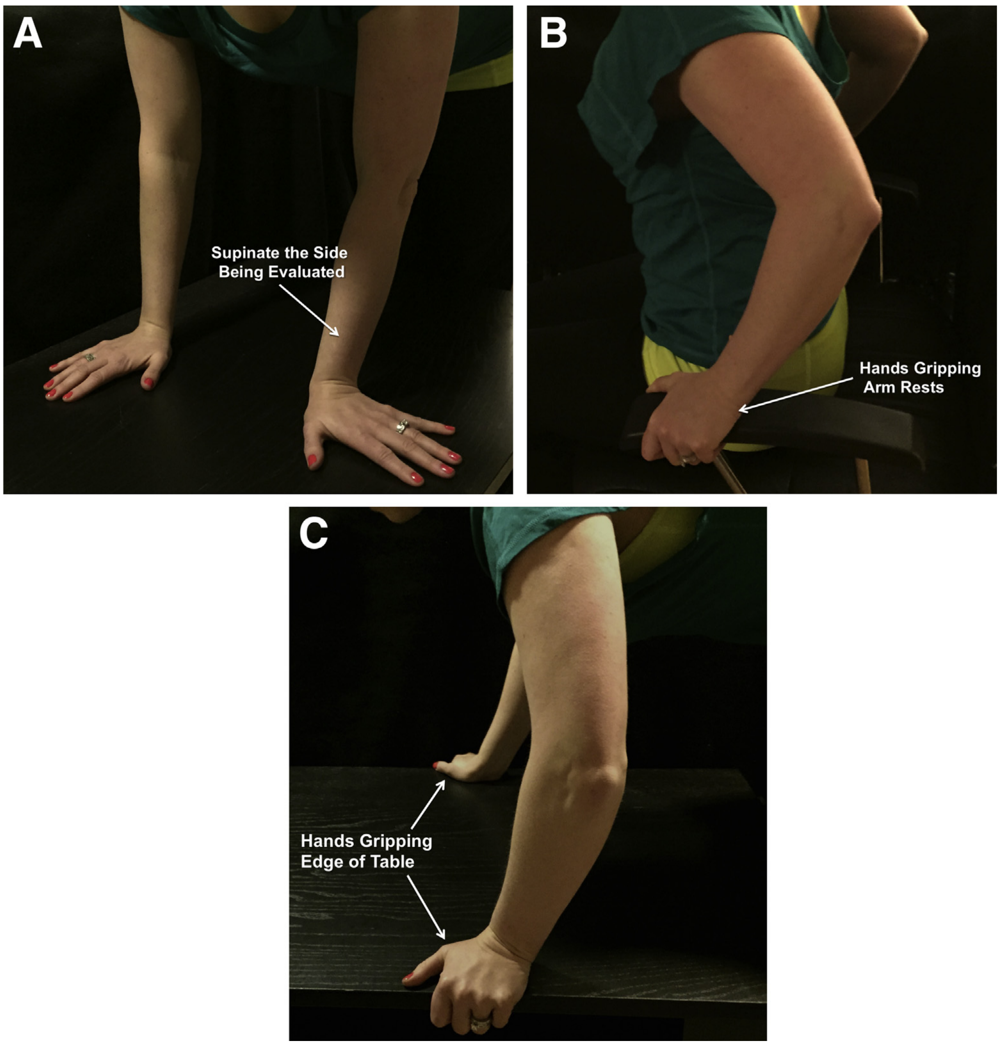

Fig 2. The prone push-up test (A), the chair push-up test (B), and the tabletop relocation test (C) are additional methods for assessing posterolateral rotatory instability. In these figures, the patient's left elbow is evaluated as they push up from a flexed and supinated position into an extended position. The patient's body weight applies the necessary axial load. Each of these examinations relies on the patient pushing themselves up, which reduces apprehension because they are in control of the force and pace. A positive test is noted when the patient experiences lateral elbow pain, instability, or apprehension.

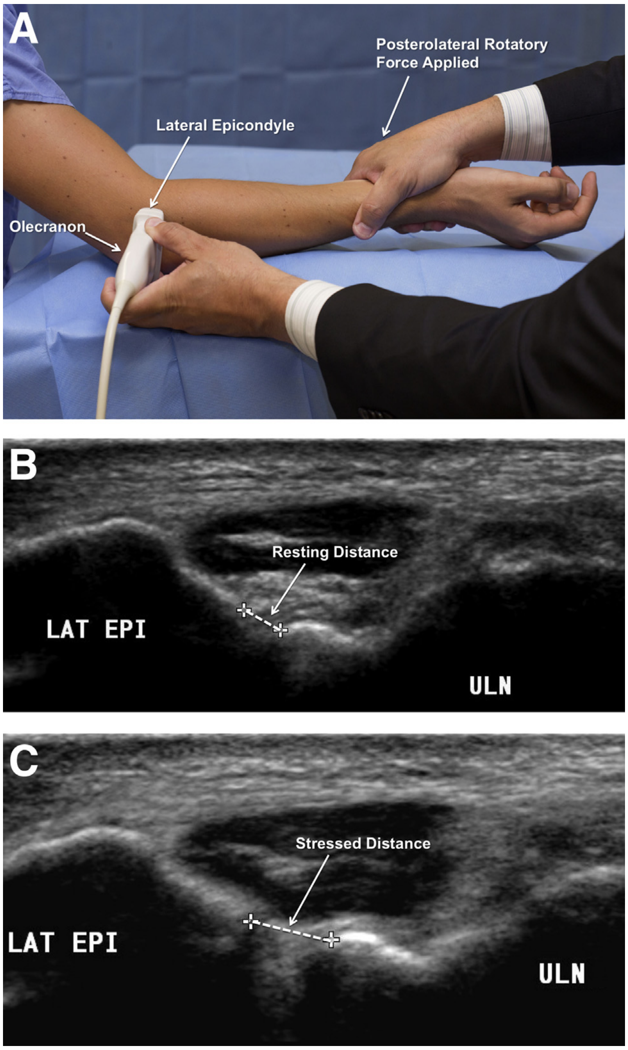

Fig 3. Ultrasound can be used to assess the elbow for posterolateral rotatory instability by measuring the extent to which the posterolateral ulnohumeral joint opens when stressed. With one hand, the ultrasonographer places the probe in the anatomic axial plane spanning from the patient's olecranon to the lateral epicondyle (A). With the other hand, a posterolateral rotatory stress is applied to the wrist or the forearm. The difference in ulnohumeral widening between the resting (B) and stressed (C) state is noted. (LAT EPI, lateral epicondyle; ULN, ulna.)

verbalize that the joint felt as though it was about to dislocate, but an actual subluxation or dislocation does not occur.

Push-up Tests

To date, a number of push-up test have been described. Nearly all are versions or modifications of 3 distinct tests: prone push-up test (standard push-up from the floor/table), chair push-up test (push-up while gripping the arm rests of a chair), and the tabletop relocation test (push-up while gripping the sides of a table)[4,5] (Fig 2). In essence, each of these tests uses the patient's body weight to create an axial load and valgus torque at the elbow, resulting in a posterolateral subluxation of the elbow while having the patient push up from the flexed and supinated elbow position. They are positive when the patient has apprehension or a sense of instability. Symptoms may improve if the test is repeated with the forearm in the pronated position or with the examiner's hand holding the radial head in the reduced position. These tests should be repeated in various degrees of pronation and supination as the instability can be positional. Examiners can also lightly place their hand over the radial head to feel the subluxation event if one does occur. Each of these push-up examinations has the benefit of giving control to the patient, but they do not allow the examiner to reliably quantify the degree of instability. They cannot be performed as a part of an examination under anesthesia.

Static Imaging

Standard anterior-posterior and lateral radiographs are often unrevealing in PLRI. They may reveal post-traumatic changes such as rim defects in the radial head, angulation of the radial neck, or an impaction fracture of the capitellum (as with a Hill-Sachs lesion of the humeral head). If the first dislocation occurred before completion of skeletal growth, there would be a high likelihood of dysplastic changes, particularly deficiency of the anteromedial coronoid. These are best appreciated on a 3D CT scan. Radiographs and CT should be evaluated for malalignment caused by malunion of a childhood supracondylar fracture, dysplasia, arthritic changes, fractures, or nonunions. Magnetic resonance imaging may be helpful in evaluating the extent of ligamentous and chondral damage; however, it is limited in that it is static and may not always identify discrete lateral ulnar collateral ligament disruption.[8]

Dynamic Imaging

Dynamic fluoroscopy or ultrasonography may prove beneficial if the diagnosis of PLRI is equivocal. Each of these tests provides a unique view of the radial head subluxation or ulnohumeral widening as a posterolateral rotatory drawer or supination torque is applied to the elbow. For the fluoroscopic examination, the elbow is viewed from a standard lateral projection while a posterolateral rotatory force is applied to the elbow. For dynamic ultrasound (Phillips Ultrasound Systems, Bothell, WA),[6] the probe is placed in the anatomic axial plane connecting the lateral epicondyle to the olecranon (Fig 3A) and the ulnohumeral joint is visualized (Fig 3B). Widening of the ulnohumeral joint is assessed as a posterolateral rotatory stress is applied (Fig 3C), and ulnohumeral laxity (stressed distance − distance at rest) > 4 mm may be indicative of PLRI.[6] These techniques and examples of positive tests are further shown in Video 1.

Discussion

A delayed diagnosis of PLRI can result in significant pain, dysfunction, and degenerative changes to the elbow. Diagnosing PLRI of the elbow can be difficult, especially in patients who are unable to relax or are experiencing significant pain. Despite this, the posterolateral rotatory drawer test and the techniques described here can be used to comprehensively evaluate the stability of the lateral side of the elbow. Outside of the posterolateral rotatory drawer test (described in Part I), the lateral pivot-shift test is the most common examination maneuver used. This technique has the advantages of being highly specific, and it allows for the assessment of severity of PRLI. It is limited in that it may be difficult to perform in the awake patient and may cause some patient discomfort. Although the push-up tests described here generally do not cause discomfort to the patient because they are in control of the examination, they do not allow determination of the severity of instability and cannot be performed in anesthetized patients. In cases in which the physical examination is equivocal or inconsistent, imaging may be a useful adjunct. Although dynamic fluoroscopy and ultrasound can readily show PLRI in many cases, further research and validation in the clinical setting is needed. Treatment, usually in the form of lateral ligament reconstruction, is warranted for symptomatic patients.

References

1. O'Driscoll SW, Bell DF, Morrey BF. Posterolateral rotatory instability of the elbow. *J Bone Joint Surg Am* 1991;73:440-446.
2. O'Driscoll SW, Spinner RJ, McKee MD, et al. Tardy posterolateral rotatory instability of the elbow due to cubitus varus. *J Bone Joint Surg Am* 2001;83:1358-1369.
3. O'Driscoll SW, Jupiter JB, King GJ, Hotchkiss RN, Morrey BF. The unstable elbow. *Instr Course Lect* 2001;50:89-102.
4. Regan W, Lapner PC. Prospective evaluation of two diagnostic apprehension signs for posterolateral instability of the elbow. *J Shoulder Elbow Surg* 2006;15:344-346.
5. Arvind CH, Hargreaves DG. Tabletop relocation test: a new clinical test for posterolateral rotatory instability of the elbow. *J Shoulder Elbow Surg* 2006;15:707-708.
6. Camp CL, O'Driscoll SW, Wempe MK, Smith J. The sonographic posterolateral rotatory stress test for elbow instability: A cadaveric validation study. *PM R* 2017;9:275-282.
7. Galway HR, MacIntosh DL. The lateral pivot shift: A symptom and sign of anterior cruciate ligament insufficiency. *Clin Orthop Relat Res* 1980;(147):45-50.
8. Terada N, Yamada H, Toyama Y. The appearance of the lateral ulnar collateral ligament on magnetic resonance imaging. *J Shoulder Elbow Surg* 2004;13:214-216.