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Clinical Sports Medicine Update

Posterolateral Rotatory Instability of the Elbow

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Symptomatic posterolateral rotatory instability (PLRI) results from a lateral collateral ligament complex injury and presents with pain, clicking, and subluxation within the flexion and extension arcs of elbow motion. Often, symptoms and examination characteristics are subtle and can be easily misdiagnosed. Therefore, a thorough history and provocative physical examination maneuvers are important to correctly establish the diagnosis. Patients frequently have a history of elbow trauma such as an episode(s) of elbow dislocation, prior surgery, or previous cortisone injections. Radiographs and advanced imaging can aid in the diagnosis, and examination under anesthesia, manipulation with arthroscopic visualization, and/or stress radiographs can be confirmatory. Symptomatic cases of PLRI can be effectively treated with a repair or isometric ligament reconstruction.

Keywords: elbow; lateral ulnar collateral ligament; posterolateral rotatory instability; reconstruction

Posterolateral rotatory instability (PLRI) of the elbow, as first described by O'Driscoll et al[33] in 1991, classically refers to an injury to the lateral ulnar collateral ligament (LUCL) that results in transient external rotatory subluxation of the ulna on the humerus, with posterior and valgus displacement. This represents the most common instability pattern in the elbow, especially in the setting of chronic symptoms.[32] This can secondarily lead to subluxation or dislocation of the radiocapitellar joint while the radioulnar joint remains intact. Over the past several decades, numerous biomechanical studies have implicated the lateral collateral ligament (LCL) complex and surrounding tissues. Ligament sectioning research has confirmed the importance of an intact overlying musculature, annular ligament, and more importantly, radial collateral ligament (RCL) and LUCL.[11,25,47] In a study by Dunning et al,[11] both the RCL and LUCL needed to be sufficiently injured in the setting of an intact annular ligament to have clinically significant PLRI. The stability conferred by the bony (radial head, coronoid process) and muscular (extensor mass, anconeus muscle) anatomy is also very important.[6]

ANATOMY

The elbow is a complex hinged joint that functions through the interplay and relationship of various muscles, bones, and ligaments. Stability is afforded through the action of static and dynamic stabilizers that ensure a very precise hinge axis of rotation about the trochlea and capitellum. The major determinant of elbow stability is the ulnohumeral joint, specifically, the coronoid, with evidence to suggest that the contribution of the olecranon to resisting loading conditions is linearly correlated with the amount of proximal ulna excised.[1] Static soft tissue stabilizers about the elbow include the medial collateral ligament (MCL; originating broadly from the anteroinferior aspect of the medial epicondyle and inserting on the sublime tubercle of the ulna) and LCL (described below). The function of these structures is based on elbow position. With the elbow in extension, the ulnohumeral articulation, anterior capsule, and MCL provide almost equal restraint to valgus translation. As the elbow approaches 90° of flexion, the MCL (in particular, the anterior bundle) provides the primary restraint against valgus translation, with the radial head becoming an important secondary stabilizer to valgus load only in the absence of the MCL.

The lateral ligament complex, presenting with some variability,[16,30,43] is a Y-shaped structure composed of the RCL, annular ligament, accessory LCL, and LUCL. The LUCL, formally described by Morrey and An[29] in 1985, originates on the lateral epicondyle, courses along the fibers of the annular ligament obliquely, and inserts at the tubercle on the crest of the supinator on the ulna. The RCL is isometric in nature. The LUCL, taut through

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the flexion-extension arc, is most isometric 2 mm anterior to the lateral epicondyle[28] and was initially considered the primary lateral stabilizer of the elbow.[30] However, recent biomechanical studies have indicated that the LCL complex as a whole contributes significantly to elbow stability on the basis of its interconnected Y-shaped anatomy, suggesting that disruption of the LUCL alone does not cause PLRI.[11,18,25,37,43,44] Despite this controversy, it is clear that these ligaments, in addition to static and dynamic support by the extensor muscles, protect the elbow against rotatory instability.[8] In terms of osseous stabilizers, the radial head plays a significant role in tensioning the LCLs and preventing the elbow from subluxating externally.[10,42] Resection of the radial head, even in the presence of intact ligaments, results in an increase in external rotatory laxity.[19,42]

CAUSE

The primary cause of PLRI involves the disruption of the LCL complex in part or in whole. It usually avulses off the lateral epicondyle[26] and is most commonly the result of trauma (frequently the result of elbow dislocation, fracture of the coronoid or radial head, etc) such as a fall on an outstretched hand[3,6,7,11,27,33,49] or any other mechanism that imparts axial compression, valgus force, and supination. Other causes of injury to the LCL complex include chronic cubitus varus, sequelae of steroid injections for lateral epicondylitis, and/or connective tissue disease.[6,7,12,21] Iatrogenic causes can include an open or arthroscopic procedure to the lateral side of the elbow[6] with inadequate repair/reconstruction of the lateral ligaments or of the common extensor, which provides some dynamic stability.[8] Resection of the radial head has also been shown to be a risk factor for the development of PLRI.[17] Similarly, there is literature to suggest that coronoid insufficiency can produce PLRI.[35]

PRESENTATION

Patients with PLRI may have pain and discomfort in the elbow as well as sensations of locking, clicking, snapping, or slipping. This is typically noted at 40° of flexion as the arm goes into extension in the arc of motion. These patients, frequently with a history of ulnohumeral dislocation, may experience a feeling of elbow instability as the elbow is brought from flexion to extension in a supinated position. They may also note a prominent radial head as it subluxates posteriorly.[33] The symptoms are more pronounced and frequent in the presence of recurrent dislocations. Expectedly, patients may attempt to prevent episodes of instability by avoiding the provocative movements and/or by guarding their elbow with a brace. A staging system (Table 1) developed for PLRI has been described by O'Driscoll[32] and may influence a patient's history, clinical examination, and choice of treatment. Patients with generalized ligamentous laxity resulting in elbow instability will have signs of lax ligaments in other joints and may have a history of instability in other joints.

TABLE 1
Staging of Posterolateral Rotatory Instability

Stage	Degrees of Capsuloligamentous Disruption[a]
1	Subluxation of the elbow in a posterolateral direction
2	Subluxation of the elbow joint with the coronoid perched underneath the trochlea
3	Complete dislocation with the coronoid resting behind the trochlea
3A	Includes the posterior band of the medial collateral ligament tear
3B	Includes the anterior and posterior bands of the medial collateral ligament tear

[a]From O'Driscoll.[32]

CLINICAL EXAMINATION

As there may be myriad reasons why patients develop lateral-sided elbow pain, a detailed history is particularly important when evaluating patients with elbow instability. The examiner must elucidate details of prior surgical procedures about the elbows and examine the location of scars about the elbow. Patients should be examined for generalized joint hyperlaxity. Physical examination of a patient with suspected PLRI can show a normal-appearing, nontender elbow. Five specific tests to elucidate symptoms of posterolateral instability have been described[6,19,21,22]:

1. The *lateral pivot-shift test*[33] can be performed in an awake patient (positive result if apprehension occurs) or under anesthesia (positive result if palpable or visible clunk). This is performed with the patient supine and the extremity over the patient's head while the shoulder is in full external rotation. With the forearm fully supinated, the examiner slowly flexes the elbow while applying valgus, supination, and axial compression (Figure 1). At 40°, rotatory displacement is maximized, and a dimple in the skin proximal to the radial head can be seen with further flexion, causing a clunk.
2. The *posterolateral rotatory drawer test*[34] can be performed by pulling posteriorly on the lateral side of the proximal forearm. Apprehension or the presence of a dimple is considered a positive result.
3. The *prone push-up test* is performed by having the patient push off the floor with elbows flexed at 90°, forearms supinated, and arms abducted. The test finding is positive if there is apprehension or radial head dislocation as the elbow extends.
4. The *chair push-up test*[39] is performed with the patient seated and elbows flexed at 90°, forearms supinated, and arms abducted. The test finding is positive if there is apprehension or radial head dislocation as the elbow extends while the patient is pushing down on the chair to rise (Figure 2).
5. The *table-top relocation test*[2,39] is performed by having the patient press up on a table using one arm with the forearm in supination. Apprehension will occur at 40° of elbow flexion and will be relieved while the examiner presses on the radial head, preventing subluxation.

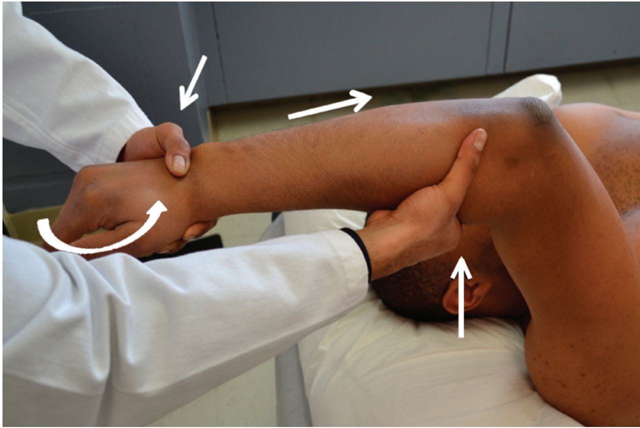

Figure 1. The lateral pivot-shift test. The patient is in the supine position. The wrist and proximal forearm are grasped securely, and a combination of supination, valgus, and axial compression is applied to the elbow. At 40° of flexion, the patient with posterolateral rotatory instability will note apprehension/pain as the radial head subluxates about the capitellum. With further flexion, a clunk or sense of relief occurs as the joint is reduced. This examination is most easily performed with the patient under sedation.

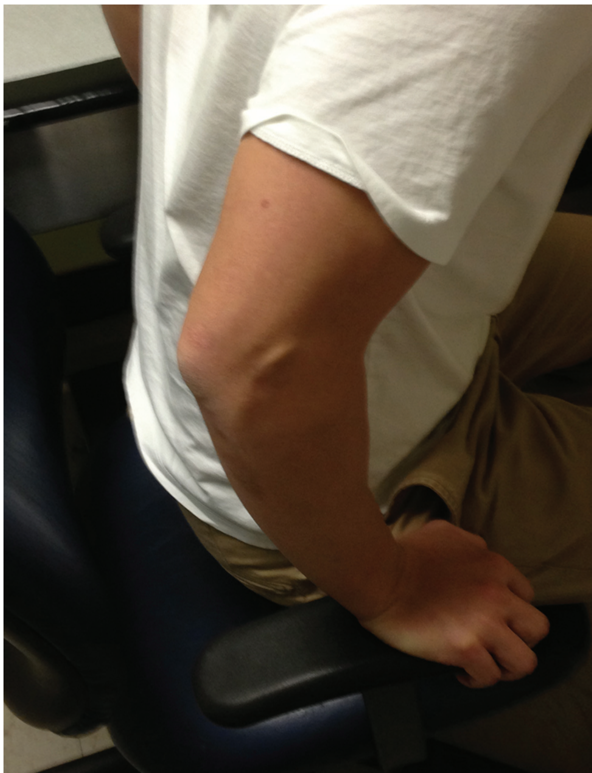

Figure 2. The chair push-up test. The patient is in a seated position with the hands grasping the arms of the chair. The elbows, in about 90° of flexion, are supinated and the arms abducted. The patient attempts to rise from the chair by pushing down. A positive result will be noted as pain as the elbow slowly extends while the patient rises.

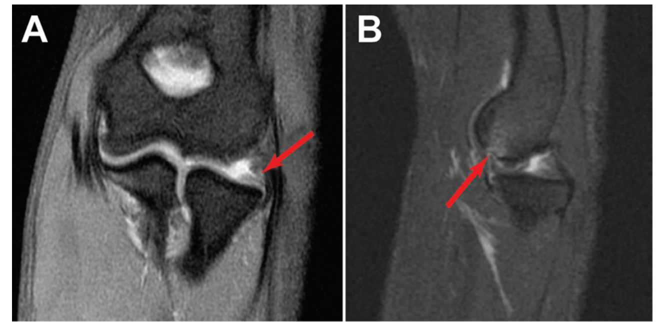

Figure 3. (A) A T2-weighted coronal magnetic resonance imaging scan of the elbow in a patient who had a fall on the elbow while skiing 2 years earlier. The image demonstrates insufficiency of the lateral ulnar collateral ligament (red arrow) and lateral subluxation of the radial head. (B) The sagittal image is notable for posterior subluxation of the radial head and a capitellar chondral defect (red arrow). On physical examination, the patient had evidence of posterolateral rotatory instability and was treated with a ligament reconstruction.

In addition to these tests, it is imperative that the examiner understands the concept of pseudo–valgus instability that may exist in the presence of an incompetent LCL complex. This false-positive valgus instability is created as the radial head falls posterior to the capitellum and the coronoid slides under the capitellum. Therefore, a precise examination of the MCL is important. This can be performed by putting the shoulder in maximum internal rotation and the elbow in pronation, which locks the radiocapitellar joint. A valgus stress is applied to the elbow at 30° of flexion, which is when the MCL is the primary stabilizer to valgus instability.

IMAGING AND DIAGNOSTIC ARTHROSCOPIC EXAMINATION

Standard anterior-posterior and lateral radiographs of the affected elbow can demonstrate slight widening of the ulnohumeral joint (drop sign) or posterior displacement of the radial head relative to the capitellum. The degree of injury to the elbow and its soft tissue structures can be assessed by identifying bony avulsions, coronoid or radial head fractures, chondral defects, and/or impaction defects in the posterolateral capitellum produced by a dislocated radial head (Hill-Sachs lesion of the elbow).[27] When the level of suspicion is high and radiograph results are normal, magnetic resonance imaging (MRI) should be performed. In addition, provocative tests can be performed with stress radiographs as described by O'Driscoll,[32] under fluoroscopy,[24] or during arthroscopic examination.[6,19,21,22]

The utility of MRI is controversial.[5,15,38,48] Potter et al[38] in 1997 demonstrated the effectiveness of MRI in the diagnosis of lateral ligament complex injuries in patients with subtle elbow instability through the use of appropriate pulse sequences.[24] Carrino et al[5] in 2001 found intermediate-weighted imaging with high spatial resolution and magnetic

TABLE 2
Summary of Studies With Reconstruction of the Lateral Ulnar Collateral Ligament

Study	Year	No. of Cases	Graft	Fixation Type	Mean Follow-up, mo	Persistent Instability, n (%)
O'Driscoll et al[33]	1991	3	Palmaris longus, triceps fascia	Bone tunnels	21	0 (0)
Nestor et al[31]	1992	8	Palmaris longus	Bone tunnels	34	1 (12.5)
DeLaMora and Hausman[9]	2002	5	Triceps fascia	Bone tunnels	Not available	0 (0)
Olsen and Sojbjerg[36]	2003	18	Triceps fascia	Bone tunnels, ulnar suture anchors	44	4 (22.2)
Lee and Teo[23]	2003	6	Palmaris longus, semitendinosus	Bone tunnels	27.8	0 (0)
Eygendaal[13]	2004	12	Triceps tendon	Interference screws	23	1 (8.3)
Sanchez-Sotelo et al[40]	2005	32	Palmaris longus, triceps fascia, tendo Achillis, plantaris, semitendinosus	Bone tunnels	69.6	2 (6.25)
Jones et al[20]	2012	8	Palmaris longus	Bone tunnels, docking technique	85.2	2 (25)
Lin et al[24]	2012	14	Palmaris longus, gracilis	Bone tunnels	49	1 (7.1)

resonance arthrography to have the greatest overall ability to enable the diagnosis of LUCL tears. Despite this, Terada et al[48] in 2004 used a similar technique and could identify the LUCL in only 50% of asymptomatic cases, concluding that MRI is not reliable for diagnosing LUCL injuries. In the clinical setting, clear imaging of the elbow is generally difficult because the joint is difficult to position in the center of the scanner.[48] However, in the presence of significant disease, damage of the lateral ligamentous complex may be clearly evident (Figure 3).

Direct visualization of the elbow joint and its surrounding structures can be performed with arthroscopic surgery as an adjunct to reconstruction. The primary advantages include the ability to evaluate medial and lateral joint space openings with stress, elbow joint arthritis, and loose fragments.[27] This can allow for accurate clinical staging and appropriate corrective surgery.[24]

TREATMENT OPTIONS

The goal for the treatment of patients with PLRI is to restore the integrity of the LCL complex, specifically the LUCL, by nonoperative or operative means. Particularly in asymptomatic patients, nonoperative measures can include avoidance of instability-causing activities, elbow bracing to limit supination and valgus loading,[6] application of a sugar tong cast,[22] pain control, and/or physical therapy. If symptoms or instability persist, operative intervention is then indicated. Operative correction of PLRI, however, is relatively contraindicated in children with open physes or anyone with concomitant arthritis of the elbow joint, generalized ligamentous laxity, or habitual recurrent dislocations.[21,22,27,49] Management of PLRI in the pediatric population continues to be controversial and can include lateral plication, ligamentous repair, or reconstruction.[22,32]

Before repair/reconstruction of the LCL complex, significant osseous deformities must be corrected. Failure to correct these deformities is likely to result in a recurrence.[4,33] In the absence of a radial head, radial head replacement should be performed. If the humerus has a significant varus deformity, a distal humerus osteotomy can be performed before management of the ligaments. It is important to assess the radiocapitellar joint at the time of repair for evidence of chondrosis or other abnormalities.

Repair of the LUCL can be performed open or arthroscopically. An open repair is typically performed via a Kocher approach and subsequent arthrotomy made anterior to the LUCL. After debridement, the LCL insertion into the lateral epicondyle is released, and the LCL complex is simply advanced and fixed to the debrided epicondyle using a Bunnell grasping transosseous suture.[27] An arthroscopic repair can use both an anteromedial portal to perform a pivot-shift test and a posterolateral portal to drive the arthroscope into the ulnohumeral joint (analogous to the "drive-through sign" in shoulder instability).[19,33] The repair is accomplished by capsular plication with absorbable sutures with or without anchor augmentation at the isometric point of the lateral epicondyle.[41] Alternatively, arthroscopic electrothermal shrinkage of the ligamentous structures for recurrent PLRI was shown by Spahn et al[45] in 2006 to increase the Morrey score (from 40 to 77), decrease lateral joint opening on stress radiography (from 13 to 2 mm), and eliminate recurrent instability at a median of 30 months. However, concern about electrothermal shrinkage in the shoulder and the unknown long-term effects make this a controversial option. We do not employ this method of treatment in our practice.

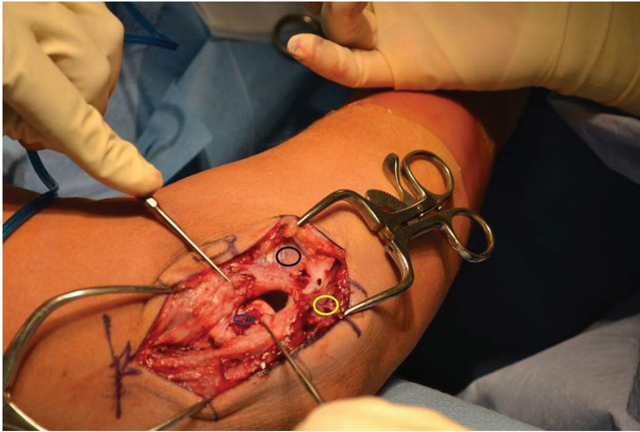

Figure 4. Lateral approach to the elbow extending into the Kocher approach distally (yellow circle in anconeus and black circle in extensor carpi ulnaris). Proximally, through the muscular interval, the lateral epicondyle is identified and noted and devoid of soft tissue.

While satisfactory results have been noted with repair,[41] sometimes repair is not feasible, and an open reconstructive technique is preferred. This may be the case when the tissue quality is too poor to successfully repair, when a prior repair has failed, or in the presence of ligamentous laxity. The time from the initial injury to definitive treatment is also a predictor of the need for a graft.[41] Ligamentous reconstruction using graft tissue can offer an isometric, extracapsular, and anatomic solution. Autogenous grafts (palmaris longus tendon, plantaris tendon, triceps tendon, gracilis, Achilles tendon, fascia lata, fourth toe extensor tendon, split semitendinosus tendon), allografts, and synthetic ligament augmentation devices have been used, but an autogenous graft is typically preferred.[6,21,22] It is critical that the grafted tendon is anchored at the isometric point with the elbow in 30° to 40° of flexion and forced pronation. An in vivo study by Moritomo et al[28] in 2007 has shown the isometric point for grafting to be 2 mm proximal to the center of the capitellum, while another study by Goren et al[14] in 2010 concluded that there is no truly isometric location. Ultimately, fixation can be achieved by bone tunnels, suture anchors, or interference screws. Thorough preoperative planning will allow for other damaged structures such as the coronoid or the MCL to be addressed at the time of surgery. Table 2 includes a summary of results noted after LCL reconstruction.

In our practice, the method of operative management varies and depends on the patient's presentation and operative findings. A fluoroscopic examination under anesthesia is performed because we believe the muscle relaxation aids in a more accurate assessment, allowing confirmation of the ligamentous incompetence. We generally use a Kocher approach, carefully identifying the interval between the anconeus and the extensor carpi ulnaris. The anconeus muscle is reflected posteriorly, and the extensor carpi ulnaris along with the extensor wad are reflected anteriorly to expose the fascia overlying the supinator crest (Figure 4). In the acute setting, if the LUCL is found to be detached but of good quality, a direct ligament-to-bone repair is performed. However, on stress examination and under direct observation, we commonly note the ligamentous complex to be of insufficient quality to be directly repaired and proceed with ligament reconstruction. In this case, we prefer to harvest the palmaris tendon as an autograft. If the palmaris is not present, we will harvest the gracilis. The principle of the reconstruction is as described by Nestor et al[31] to identify the isometric point on the humerus, which is performed by passing a suture through the ulnar tunnels and approximating it to the location on the humerus, at which it is taut from flexion to extension. On the ulnar side, we use the anatomic insertion of the native LUCL at the supinator crest as well as a point 2 cm proximal to this site and near the base of the annular ligaments as anatomic landmarks for the ulnar tunnels. Once the bony tunnels are established and the graft is appropriately shuttled, we prefer the docking technique, with 2 ulnar tunnels and 1 humeral tunnel at the approximate isometric point, as described by Jones et al[20] to secure the graft (Figure 5). Particular attention is paid to trim the graft to the appropriate length before docking it into the humeral tunnel to ensure that the graft will not exceed the length of the tunnel. We also imbricate any native capsuloligamentous tissue at the humeral epicondyle with a heavy

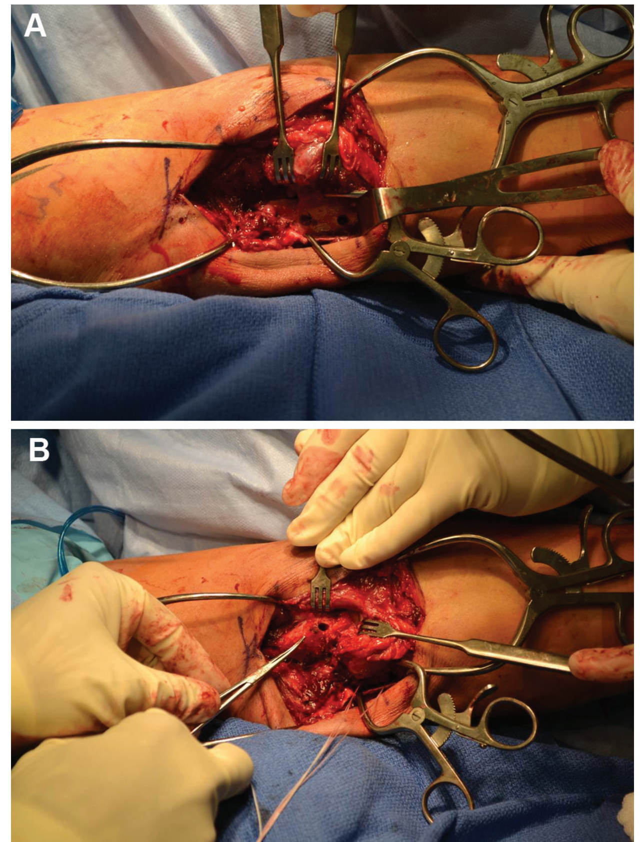

Figure 5. (A) Two 4-mm tunnels spaced approximately 2 cm apart are made. The distal hole is at the level of the tubercle on the supinator crest. (B) A 4-mm humeral tunnel is drilled at the approximate isometric point.

braided suture over the graft to augment the strength and healing of the reconstruction. In the case of a large patient or if there is concern about the strength of our graft, we will maintain enough length on the graft so that we can imbricate an extra limb of the graft unto itself so that we have a "3-strand" as opposed to a "2-strand" construct. We typically repair the extensor muscle wad to the lateral humeral epicondyle using a small bioabsorbable suture anchor, taking care to avoid the trajectory of the humeral tunnel, to achieve a stable reconstruction.

Other reconstructive techniques and modifications have been described. A split anconeus fascia has been described by Stein and Murthi.[46] This technique can only be performed in the presence of an intact anconeus fascia and provides the advantages of a local autograft that is biomechanically strong and minimizes the number of bone tunnels needed. Using the Kocher approach, they identified the anconeus fascia and detached it distal to proximal for an 8 × 1–cm graft, leaving the ulnar insertion intact.[46] This fascial band is then split longitudinally. The individual bands are then docked into a humeral tunnel created at the approximate isometric point.[46]

POSTOPERATIVE MANAGEMENT

The arm should be immobilized in a posterior splint with the elbow in midpronation to full pronation and 90° of flexion for approximately 1 to 2 weeks, after which the elbow can be placed in a neutral position within a hinged elbow brace for 4 to 6 weeks, allowing for 30° of extension and 90° of flexion. During this time, the patient should stay in the brace at all times, and range of motion can be gradually increased on a weekly basis, depending on the recovery. These parameters are increased until full extension and flexion are achieved. Range of motion exercises for the wrist and hand are permitted without restriction. At 3 months, elbow strengthening exercises and range of motion exercises are initiated along with any sport-specific rehabilitation protocol. Most patients can return to full activity or sports by 4 to 6 months.[20,27,49]

COMPLICATIONS

Despite an accurate repair or reconstruction, instability can still occur. In a study by Jones et al,[20] they noted a recurrence rate of 25% in 8 patients treated with the docking technique at a mean of 7 years. Nestor et al[31] reported on 11 patients (3 repairs and 8 reconstructions) who underwent surgery for PLRI, with 3 patients with fair outcomes and 1 with a poor outcome according to their classification. All 3 patients who underwent repairs noted excellent outcomes. However, these patients had less disease than those who underwent reconstructions. The authors noted prior surgery to be a potential risk factor for poor outcomes and also noted the presence of radiocapitellar arthrosis to be a poor prognostic sign.[31] It is therefore imperative that patients are counseled as such and that the quality of the joint is assessed preoperatively and during surgery. Sanchez-Sotelo et al[40] reported their outcomes in 44 (12 repairs and 22 reconstructions) patients who underwent surgery for PLRI. Five patients (11%) noted further instability, and 27% of patients described fair or poor results. One must understand that patients may have recurrent instability despite correction of the pivot shift on examination. Despite recurrence and arthrosis representing the most significant complications, others include infection, bony bridge fracture, cutaneous nerve injury, and arthrofibrosis resulting in flexion contracture.[6,27,49]

SUMMARY

The LCL complex includes an ensemble of structures that, when sufficiently injured, can result in PLRI of the elbow. The diagnosis can be accurately made with a combination of history, physical examination, imaging, and arthroscopic surgery. Symptomatic PLRI can be effectively managed with ligamentous repair or reconstruction in either an open or arthroscopic fashion. Although the most common complication is recurrent instability, the majority of patients return to full activity by 6 months.

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