Chapter 27
Elbow Instability and Reconstruction
Bradford O. Parsons, MD  Matthew L. Ramsey, MD

Arthritis

Osteoarthritis
Osteoarthritis of the elbow joint can occur primarily or secondary to trauma. Primary osteoarthritis usually occurs in middle-aged men who often have performed manual labor. In the early stages, nonsurgical management with nonsteroidal anti-inflammatory drugs, activity modification, and corticosteroid injections can be helpful. Arthroscopic débridement and synovectomy, and débridement or interpositional arthroplasty are generally recommended for younger, active patients who do not respond to nonsurgical management. For older and more sedentary patients, total elbow arthroplasty is considered the procedure of choice.

A 2008 study reported on arthroscopic osteophyte resection and capsulectomy in 41 patients with primary osteoarthritis. At follow-up of more than 2 years, the authors identified significant improvements in flexion and extension, supination, and functional scores. Many patients (81%) reported good to excellent results with a significant decrease in pain; complications were rare.

In a study with seven patients, the outcomes of treating osteochondral lesions in the elbow with autologous osteochondral transplantation were reported. The grafts were harvested from the lateral femoral condyle. Significant improvements occurred in pain and functional scores. Gift viability was confirmed in all patients with postoperative MRI.

A recent study reported on 11 patients younger than 50 years who were treated with arthroscopic ulnohumeral arthroplasty for degenerative arthritis of the elbow after failed nonsurgical treatment. An all-arthroscopic technique was used. It was concluded that the procedure resulted in significant short-term pain relief, restoration of motion, and improved function.

In a recent radiographic study of arthritic elbows using CT scanning, a higher incidence of ulnohumeral osteophytes (95%) was identified compared with radiocapitellar joint osteophytes (59%). The study authors challenged the notion that osteoarthritis originates in the radiohumeral joint.

Inflammatory Arthritis

The Larsen classification is generally used for the stratification of elbow joint involvement in rheumatoid arthritis (Figure 1). Surgical arthroscopy remains an important modality for treatment, especially when the inflammatory component is significant and the bony structures are relatively well preserved.

In a study reviewing the use of either open or arthroscopic synovectomy in 58 rheumatoid elbows, no significant differences between the techniques were identified in elbows with a preoperative arc of flexion of less than 90°. In patients with an elbow arc of motion greater than 90°, arthroscopic synovectomy provided better function than the open approach.

In patients with inflammatory changes with symptoms and dysfunction refractory to nonsurgical measures, semiconstrained total elbow arthroplasty remains a reliable method of treatment. A 2009 study compared complication rates between patients with and without rheumatoid arthritis who were treated with total elbow arthroplasty. Data from 3,617 patients were analyzed; 888 patients were identified as having rheumatoid arthritis and the remainder were classified as nonrheumatic patients. Complication rates were low in both groups; however, there were more medical complications and longer hospital stays in the nonrheumatic group. The authors concluded that complications after total elbow arthroplasty were rare and nearly equivalent in rheumatoid and nonrheumatoid patients.

In 49 patients age 40 years or younger treated with total elbow arthroplasty (6 bilateral procedures), 30 patients had inflammatory arthritis and 19 had post-
traumatic arthritis. During the recorded follow-up (minimum of 5 years), 12 of the elbows required a second surgical procedure. The rate of revision was higher for patients with posttraumatic arthritis.

**Stiffness**

Loss of motion after injury or elbow surgery can lead to significant functional disability. Although the exact cause of the development of elbow contracture remains unclear, several factors have been theorized to contribute to this disorder, including the high degree of congruity of the elbow joint, its propensity for developing heterotopic bone, cocontraction of the periarticular muscle groups, and irritability of the ulnar nerve.

Treatment of posttraumatic or postoperative elbow stiffness can be unreliable. As a result, prevention with range-of-motion exercises and other modalities, including static progressive splinting, is critical in managing these patients (Figure 2). Any injury that does not require surgical treatment (for example, nondisplaced radial head fractures) should be treated with an early range-of-motion program. Injuries that require surgical treatment should be fixed in a stable manner so that the rehabilitation process can begin a few days following the surgical procedure.

If nonsurgical management fails to restore mobility, arthroscopic or open contracture release can restore motion in patients with dysfunction. Arthroscopic release is generally reserved for patients with mild contractures, whereas open releases are performed in patients with severe stiffness, a significant amount of heterotopic bone, or those with ankylosis. Manipulation under anesthesia is commonly performed in the knee for treating stiffness following total knee arthroplasty. In 51 patients treated with manipulation under anesthesia for contracture release of a stiff elbow an average of 40 days after surgery, the mean postmanipulation arc of motion increased to 78° from 40° preoperatively. The authors concluded that manipulation under anesthesia is a safe and valuable adjunct in the treatment of elbow stiffness.

Continuous passive motion (CPM) after elbow contracture release has been used to maintain motion in the early postoperative period. CPM after open contracture release in two matched cohorts of 16 patients was evaluated in a 2009 study. The preoperative arc of motion (flexion and extension) averaged 38° in the CPM group and 42° in the group with no CPM. The improvement and the final arc of motion between both groups were comparable, differing by 5°. The authors concluded that there was no demonstrable benefit of postoperative CPM after open contracture release.

**Elbow Instability**

The elbow joint is stabilized by a combination of static and dynamic constraints. The static stabilizers are divided between a set of primary and secondary stabilizers. The primary stabilizers of the elbow include the ulnohumeral articulation (coronoid process), the medial collateral ligament (MCL), and the lateral collateral ligament (LCL) complex. The secondary stabilizers include the radiocapitellar articulation and the common flexor and extensor origins. The anterior capsule also

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**Figure 1** Larsen classification system for the rheumatoid elbow. A, Stage I: normal architecture and osteoporosis. Synovitis is present. B, Stage II: joint-space narrowing and intact joint architecture. Synovitis is present. C, Stage III: alteration of joint architecture. D, Stage IV, gross joint destruction and minimal synovitis. (Reproduced from Athwal GS, Faber KJ, King GJW: Elbow reconstruction, in Fischgrund JS, ed: Orthopaedic Knowledge Update 9. Rosemont, IL, American Academy of Orthopaedic Surgeons, 2008, pp 333-342.)

**Figure 2** A progressive static splint is used to manage elbow stiffness. (Reproduced from Bruno RJ, Lee ML, Strauch RJ, Rosenwasser MP: Posttraumatic elbow stiffness: Evaluation and management. J Am Acad Orthop Surg 2002;10(2):106-116.)
contributes to the stability of the elbow as an anterior restraint, especially in terminal extension. Further stability is conferred by the action of the muscles spanning the elbow, including the brachialis, triceps, and anconeus, which impart compressive forces across the joint. Traumatic injury to any single primary stabilizer may lead to elbow instability, with most injuries involving a spectrum of pathology.

In addition to acute instability, a variety of recurrent instability patterns of the elbow have been described, including posterolateral rotatory instability, varus posteromedial rotatory instability, and valgus instability. Chronic dislocation or failed management of complex instability may also occur, although more rarely.

**Recurrent Instability**

Recurrent instability of the elbow is rare and often subtle, with most patients describing pain as the primary symptom. A history of recurrent dislocation is extremely rare. As such, a high index of suspicion is required to diagnose this condition because static imaging studies may appear normal and physical examination findings may be limited by pain and guarding. Three pathologic entities of recurrent instability have been described: posterolateral rotatory instability, varus posteromedial rotatory instability, and valgus instability. A new classification of fractures of the coronoid process has furthered the understanding of the role of this structure in these instability patterns (Figure 3).

**Posterolateral Rotatory Instability**

The most common etiology of symptomatic recurrent instability occurs following injury to the LCL, specifically the lateral ulnar collateral ligament (LUCL) complex, resulting in posterolateral rotatory instability. This condition describes a sequence of instability that occurs with supination, axial loading, valgus stress, and extension of the elbow, resulting in subluxation of the radial head posterior to the capitellum, and rotation of the semilunar notch away from the trochlea. Most commonly, posterolateral rotatory instability occurs following traumatic injury (elbow dislocation), which can result in an attenuated LUCL complex. Other etiologies also have been described, including iatrogenic injury during lateral elbow procedures, such as lateral epicondylitis release, or from progressive ligament attenuation secondary to chronic cubitus varus malunion.

Most patients with posterolateral rotatory instability report pain and occasional “catching” or “clunking” sensations, often when pushing off from the arm of a chair. The lateral pivot-shift test has been shown to be a provocative test that can identify posterolateral rotatory instability, although it can be difficult to perform in an awake patient because of apprehension and guarding (Figure 4). This test is often more reliable in an anesthetized patient. The test is performed with the arm flexed over the head of a supine patient. The forearm is supinated, elbow extended, and a valgus load is placed across the elbow. In this position the elbow is subluxated. As the elbow is slowly flexed, maintaining a supinated forearm and valgus load, the radial head will reduce, often with a clunk (in an anesthetized patient), confirming LCL insufficiency. When performed under fluoroscopy, the radial head can be visualized posterior to the capitellum on lateral imaging when the elbow is extended. Additionally, the ulnohumeral joint can appear widened; both the radiocapitellar and ulnohumeral joint congruencies are restored to normal with elbow flexion.

More recently, other diagnostic tests have been described, including the tabletop relocation test, chair push-up test, and floor push-up test. All of these tests mimic the subluxating force associated with posterolateral rotatory instability, involving active extension of the elbow with the forearm supinated and the hand on a platform (either the floor, table, or armchair). In all
A variety of reconstruction techniques have been described, often because of attenuation or rupture of the native ligament tissue. However, repair of posteromedial rotatory instability yields inferior results to reconstructions with tendon graft, often because of attenuation or rupture of the native ligament tissue.

Varus Posteromedial Rotatory Instability
More recent attention has focused on fractures involving the anteromedial facet of the coronoid, resulting in a complex pattern of instability termed varus posteromedial rotatory instability. This type of instability develops as a result of injury to the anteromedial facet of the coronoid and rupture of the LCL complex. In this setting, a varus force fractures the anteromedial facet of the coronoid with rupture of the LCL, leading to subluxation of the ulnohumeral joint into the defect created by the anteromedial coronoid fracture. As a result, fracture to the anteromedial facet can be subtle but can lead to significant ulnohumeral instability. An important aspect of anteromedial facet injuries in relation to elbow stability is the involvement of the sublime tubercle, which is the insertion point of the anterior bundle of the MCL.

The mechanism of injury is different from the valgus stress to an axially loaded and supinated forearm that is involved in posterolateral rotatory instability. In posteromedial rotatory instability, the radial head does not impact the capitellum, as occurs in most fracture-dislocations of the elbow; therefore, the radial head is often spared. Repair of posteromedial rotatory instability requires both a medial and lateral approach that fixes the coronoid fragment and repairs the LCL complex.
plex. In a biomechanical study, it has been shown that it may be possible for small subtype I anteromedial coronoid fractures to be managed with isolated repair of the LCL if the MCL is intact.22

To identify posteromedial rotatory instability, a high index of suspicion is required because elbow radiographs may appear relatively normal on AP and lateral views. Some radiographic clues may include a double density of the coronoid subchondral plate on lateral images, or a narrowing of the anteromedial ulnohumeral joint space on AP images. Varus stress radiographs may highlight LCL insufficiency and show trochlear-coronoid contact. CT scans can help identify the anteromedial coronoid fracture and confirm the diagnosis (Figure 6).

Although the diagnosis may be difficult, it is critical because nonsurgical treatment often results in persistent incongruity of the elbow, altered kinematics, and early arthrosis of the ulnohumeral joint.20,22 Surgical treatment is necessary to restore the coronoid architecture, often using an anteromedial buttress plate via a medial approach, followed by LCL isometric repair. At an average follow-up of 26 months, 18 patients with anteromedial facet fractures of the coronoid were evaluated.21 Six patients had varus subluxation of the elbow; four had not had fixation of the anteromedial facet and two had loss of fixation. Arthrosis developed in all six of these patients; results were fair to poor. The 12 patients with secure fixation of the anteromedial facet fracture had good to excellent elbow function.

Early range of motion is started after surgical repair.21 Anatomic repair and healing of the coronoid and LCL has yielded favorable results.20

Valgus Instability
Disruption of the MCL, specifically the anterior band of the MCL, can result in recurrent valgus instability of the elbow. MCL injuries may occur secondary to trauma (such as a dislocation) or as the result of repetitive stress (most commonly observed in throwing athletes). As opposed to lateral-sided instability, medial instability was historically believed to be well tolerated in most patients because little valgus load is placed across the elbow during the activities of daily living. Secondary stabilizers such as the radial head often minimize the severity of instability so that frank recurrent dislocation is rare. As such, findings of valgus instability may be subtle, and often can be confused with medial epicondyliitis or an inflamed cubital tunnel.

Most patients who report symptomatic valgus instability are overhead athletes, predominantly baseball players. The elbow is subjected to a high valgus load during the acceleration phase of throwing, placing tremendous stress on the anterior band of the MCL. Throwers may report experiencing a “pop” associated with a sudden drop in velocity following acute rupture of the anterior band of the MCL. However, some patients cannot identify any cardinal event and primarily report pain during throwing motion, or a loss of velocity or accuracy. Adding to the diagnostic difficulty, many throwers with anterior band MCL insufficiency also report posteromedial elbow pain resulting from posteromedial impingement of the olecranon during the deceleration phase of throwing, termed valgus extension overload.

The physical examination centers on provocative testing of the MCL. Tenderness is often elicited over the MCL origin. Integrity of the flexor pronator mass is assessed, as is the ulnar nerve and cubital tunnel. Posteromedial tenderness over the olecranon may indicate valgus extension overload. A variety of provocative maneuvers have been described to identify MCL injury, including the valgus stress test, milking maneuver, and moving valgus stress test. Valgus stress testing is performed with the elbow in 30° flexion, unlocking the olecranon from the fossa. The milking maneuver is performed with the elbow in 90° flexion. With the examiner holding the patient’s ipsilateral thumb, a valgus stress is placed on the elbow with the forearm supinated. Pain at the MCL origin is considered a positive finding. More recently, a variant of the milking maneuver, the moving valgus stress test, was reported to be 100% sensitive and 75% specific for MCL injury when compared with arthroscopic or open visualization of the ligament.23 In this maneuver, the arm is positioned in the same manner used in the milking maneuver, but the elbow is taken through a range of motion while a maximal valgus stress is applied across the joint. Reproducible pain in the medial elbow between 70° and 120° is considered a positive test.

Similar to posterolateral and posteromedial rotatory instability, static radiographs of patients with valgus instability are often normal. A posteromedial osteophyte of the olecranon in patients with valgus extension overload may be apparent on radiographs but is often sub-
tle. Valgus stress radiographs may show medial ulnohumeral joint widening, especially in posttraumatic valgus instability. MRI can be helpful in identifying acute ruptures of the anterior band of the MCL, chronic thickening associated with repetitive injury, and injury to the flexor-pronator origin.

Patients with symptomatic valgus instability are initially managed nonsurgically, with therapy aimed at strengthening the flexor-pronator muscles, along with rest from throwing for a minimum of 6 weeks. Patients can resume throwing if symptoms abate, with careful attention placed on throwing mechanics. Nonsurgical treatment has been used with success in some throwing athletes, with 13 of 31 athletes (42%) returning to their preinjury level of sports activity at an average of 24 weeks following rehabilitation and rest.24

If nonsurgical treatment is unsuccessful, patients can be candidates for MCL reconstruction with tendon graft. Primary repair, as is the case in posterolateral rotatory instability, is often inferior to reconstruction in recurrent valgus instability, except in rare cases of early identification of acute avulsion injuries.25 Similar to LUCL reconstruction, a variety of reconstruction techniques for the anterior band of the MCL have been described, including figure-of-8 graft passage through the ulnar and humeral tunnels, docking techniques, and the use of fixation devices such as Endobuttons (Smith & Nephew, Memphis, TN) or interference screws with single- or double-strand tendon grafts. Recently, a biomechanical study evaluated four conventional reconstruction methods: figure-of-8 fixation, humeral docking, interference screw fixation, and single-strand Endobutton reconstruction. The humeral docking and Endobutton techniques were stronger than the figure-of-8 and interference screw fixation methods, although none were as strong as the native ligament.26 Conversely, another biomechanical analysis found that interference screw fixation of the ulnar side, associated with humeral docking, yields graft fixation strength equal to 95% of that provided by the native MCL under valgus loading.27

Conventional approaches use a flexor-pronator split rather than the original technique with reflection of the flexor mass off the epicondyle in an effort to preserve the role of the flexor group as a dynamic stabilizer of the medial elbow. Management of the ulnar nerve is dictated by the presence of preoperative ulnar nerve symptoms; routine transposition has been abandoned because of the potential for ulnar nerve irritation. Although not truly isometric, the anterior band of the MCL is nearly isometric, with the origin at the center of rotation of the medial aspect of the trochlea; humeral fixation should be placed at this site.26

Results following reconstruction have been excellent, with most series reporting more than 90% of patients returning to preinjury levels of throwing and sports participation.28-30 Few clinical data are available to demonstrate the superiority of one technique over another.

### Chronic Instability

Chronic instability of the elbow is rare. Management of a chronic simple dislocation or the more common complex dislocation is challenging, with results inferior to those obtained following appropriate closed treatment or surgical management of an acute dislocation. Failed prior surgical stabilization, especially following complex instability, is the most common etiology of chronic instability and requires careful assessment of the osseous and ligamentous structures critical for elbow stability. In addition to the inherent ligamentous and osseous pathophysiology, articular derangement is often present, as are fibrous adhesions of the joint that fill the widened joint space of a chronically dislocated elbow. Heterotopic ossification, which may encase the neurovascular structures around the elbow, adds complexity to treating the disorder. The periarticular muscles, especially the triceps, are often contracted, potentially requiring lengthening or release. Most studies show that closed reduction of a chronically dislocated elbow is unlikely to achieve successful restoration of stability or function, especially after 3 to 4 weeks of being dislocated.31

Surgical management is aimed at concentric reduction of the joint, with removal of any fibrous tissue or adhesions preventing reduction, ligament reconstruction, and triceps lengthening (when necessary). Chronic complex dislocations require restoration of the osseous constraints, especially the coronoid process. Unfortunately, coronoid insufficiency is frequently present after neglected or failed prior surgical stabilization of terrible triad injuries, and carries a guarded prognosis, especially when bone loss exceeds 50%. Reconstruction of coronoid bone loss is very challenging.32

Hinged external fixation is often required when managing the chronically dislocated elbow, and has been used with success in limited series.33,34 When greater then 50% of the articular surface is damaged, interposition arthroplasty or prosthetic replacement is considered, depending on the patient’s physiologic age and activity level. Regardless of the reconstructive technique, patients should be aware of the potential goals of treatment, which are restoration of concentric reduction and a functional range of motion. Persistent pain and limitation of motion, especially in extension, often occur following successful management of this complex disorder.

### Annotated References


In this series the authors present the retrospective results of 41 patients who underwent arthroscopic osteophyte removal and capsulectomy. At minimum 2-year follow-up, total flexion improved from 117.3° to 131.6° and extension improved from 21.4° to 8.4°. Overall the au-

This series reviews the results of seven patients with osteochondral lesions of the elbow (five capitellar, one trochlea, and one radial head) who were managed with autologous lateral femoral condyle cylindrical osteochondral plugs. At an average follow-up of 59 months, Broberg-Morrey and pain scores were significantly improved and all grafts were viable and congruent on MRI scans.


In their series of 11 patients younger than 50 years with symptomatic elbow osteoarthritis managed by arthroscopic ulnohumeral arthroplasty, the authors demonstrated an average improvement in arc of motion of 73˚ and improved pain scores at minimum follow-up of 2 years.


In a consecutive series of 22 patients with osteoarthritis of the elbow, 95% of patients demonstrated ulnohumeral osteophytes on three-dimensional CT scans. Conversely, radiohumeral osteophytes were observed in only 59% of patients.


Using data analyzed from the Nationwide Inpatient Sample database, the authors found that in 3,617 total elbow arthroplasties, overall complication rates were low and nearly equivalent between patients with rheumatoid arthritis (888 patients) compared to other diagnoses. Length of stay was longer in patients without rheumatoid arthritis.


The authors retrospectively reviewed the results of 49 patients (55 elbows) younger than 40 years with elbow arthritis managed with total elbow arthroplasty. Thirty patients had a diagnosis of inflammatory arthritis, and the remaining 19 patients, posttraumatic arthritis. At an average follow-up of 91 months, 22% of elbows had undergone additional surgery, and 93% (51) were graded as good-excellent according to Mayo Elbow Performance Scores. The revision rate is higher in patients with a posttraumatic etiology.


In a series of 44 patients with stiff postsurgical elbows, an examination (with manipulation) of the elbow under anesthesia at a mean postoperative date of 40 days yielded an improvement in arc of motion from 33˚ to 73˚. Three patients had worsening of ulnar paresthesias, with one requiring ulnar nerve transposition.


In a retrospective matched series of patients undergoing open contracture release of stiff elbows, outcomes were compared between 16 patients who underwent postoperative CPM compared with 16 control subjects. At final follow-up of 6 months, no difference was observed in flexion or extension motion between groups.


The authors report on a series of 54 patients with posterolateral rotatory instability of the elbow managed with open repair or reconstruction (30 patients) or arthroscopic repair (24 patients). The authors report improvement in Andrews-Carson scores of 145 to 180 at an average follow-up of 41 months. Acute repairs (10) demonstrated the best outcome, and no difference was observed between open and arthroscopic repairs. Level of evidence: IV.

15. King GJ, Dunning CE, Zarzour ZD, Patterson SD, Johnson JA: Single-strand reconstruction of the lateral ulnar collateral ligament restores varus and postero-


The authors evaluated 18 patients with anteromedial facet coronoid fracture and varus posteromedial rotatory instability. Early unihumereral arthrodesis developed and a fair or poor outcome was reported in six patients with coronoid fracture malalignment. The remaining 12 patients with anatomic coronoid healing had good or excellent elbow function. Level of evidence: III.


Using an in vitro cadaver model, the authors assessed the impact of the size of an anteromedial facet coronoid fracture on elbow stability and kinematics. Elbows with subtype I and repaired LCL demonstrated kinematics similar to an intact elbow. Subtype II and III fractures were unstable with varus and valgus stress.


The authors report on a study of 11 collegiate athletes with acute rupture of the anterior band of the MCL. After MCL repair, 9 of 11 patients returned to college athletics. Level of evidence: IV.


Following DANE TJ reconstruction of the ulnar collateral ligament of the elbow, 19 of 22 patients had excellent Conway scores at a mean follow-up of 36 months. Level of evidence: IV.


The authors present a review of current options for treating a chronically dislocated elbow.


At a minimum 2-year follow-up, 13 of 21 patients (62%) treated for chronic instability with associated coronoid fracture had successful objective outcomes. Eight patients had persistent elbow instability; 16 patients required hinged external fixation as part of their treatment. Level of evidence: IV.
