Minimally Invasive Treatment of Lateral Ulnar Collateral Ligament Injury

Steven J. Lee and Matthew Mendez-Zfass

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Abstract
Reconstruction of the lateral ulnar collateral ligament is undertaken in situations of isolated ligament injury as well as in cases of fractures or fracture dislocations with instability following reduction. This chapter reviews the bony and ligamentous anatomy of the elbow, the physical exam findins associated with posterolateral rotatory instability as well as surgical treatment considerations. Finally, a minimally invasive technique for reconstruction of the lateral ulnar collateral ligament (LUCL) is presented which can be used in cases of isolated posterolateral instability (PLRI) or more severe elbow injurys and may obviate the need for hinged external fixation.

Keywords
Lateral ulnar collateral ligament • Elbow • Posterolateral rotatory instability • Supinator crest • Terrible triad • Internal brace • Reconstruction

Introduction

Reconstruction of the lateral ulnar collateral ligament is undertaken in situations of isolated ligament injury as well as in cases of fractures or fracture dislocations with instability following reduction. O'Driscoll et al. [1] described posterolateral rotatory instability (PLRI) of the elbow as occurring from an injury to the lateral ulnar collateral ligament (LUCL) that leads to a

S.J. Lee (✉) • M. Mendez-Zfass
Department of Orthopeadics, NISMAT: Nicholas Institue of Sports Medicine and Athletic Trauma, Lenox Hill Hospital, New York, NY, USA
e-mail: sjleemd@aol.com; teomendezmd@gmail.com

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characteristic instability pattern. With deficiency of the LUCL, the ulna is able to externally rotate on the humerus with a posterior and valgus force, which can lead to transient disruption of the radiocapitellar joint and posterior displacement of the radial head. While necessary to lead to instability, an isolated injury of the LUCL has been found in biomechanical studies to not be sufficient for development of PLRI. A cadaver study by Dunning et al. [2] demonstrated the need for both the radial collateral ligament (RCL) and LUCL to be injured in order to develop PLRI. Other biomechanical studies have emphasized the various contributions of intact annular ligaments as well as the contributions of the dynamic muscle stabilizers [3].

Clinically however, the treatment of these injuries has traditionally involved isolated reconstruction of the lateral ulnar collateral ligament that has been found to reproducibly alleviate symptoms and restore stability. The original surgical description by O'Driscoll involved reattachment of the avulsed LUCL to the lateral epicondyle [1]. Since then, there have been multiple described techniques for surgical reconstruction of the LUCL with excellent results [4–8].

This chapter will summarize the injury, relevant anatomy, and physical exam findings and give an overview of the historical techniques used for surgical reconstruction. In addition, it will provide the authors' preferred method of reconstruction and augmentation using novel surgical techniques.

Anatomy

The elbow joint is a complex synovial-hinged joint that consists of three separate articulations: the ulnohumeral, radiocapitellar, and proximal radioulnar joints. These three articulations allow the elbow 2 ° of freedom: flexion and extension as well as supination and pronation. In addition, the bony congruency of these three articulations, when combined with the surrounding ligamentous, capsular, and dynamic structures, serves to provide stability to the elbow throughout physiologic forces and ranges of motion. In contradistinction to the knee, there are no intra-articular cruciate ligaments that provide stability to the elbow.

Osseous Anatomy

The distal humeral and proximal radioulnar osseous anatomy is congruent and provides a degree of inherent stability to the elbow joint. The humerus fans out distally to lateral and medial epicondyles that serve as attachment points for the collateral ligaments. The distal humerus has 6–8° of valgus tilt and 3–8° of internal rotation when comparing the epicondylar axis and the humeral shaft. Additionally, the distal humeral articular surface angle is approximately 30 ° anterior to the humeral shaft axis (Fig. 1).

Continuing distally from the epicondyles, the distal humerus has two condyles that form the articular surfaces laterally and medially. The lateral condyle forms the articular surface of the capitellum that articulates with the radial head (Fig. 2).

The concave radial head and the convex capitellum create the radiocapitellar joint. The bony congruency of the radiocapitellar joint as well as the radial head in the lesser sigmoid notch of the ulna provides approximately 240 ° of radial head rotation. The trochlea articulates with the greater sigmoid notch of the ulna that consists of the olecranon posteriorly and the coronoid anteriorly (Fig. 3). During extension, the olecranon "screws out," creating a valgus carrying angle, while during flexion the olecranon "screws in," creating a normal varus angle [9–11].

The surface anatomy of the lateral epicondyle is distinct from that of the medial epicondyle with respect to its corresponding ligamentous attachments. The Ulnar Collateral Ligament (UCL) attaches to the *undersurface* of the medial epicondyle, which forms a type of shelf that makes it obvious as to where the true origin of the UCL should be (Fig. 4).

The LUCL however attaches on the *surface* of a broad, rounded convexity of the lateral epicondyle. Since the LUCL injuries often tear proximally off the lateral epicondyle, the exact origin of which is difficult to discern, especially

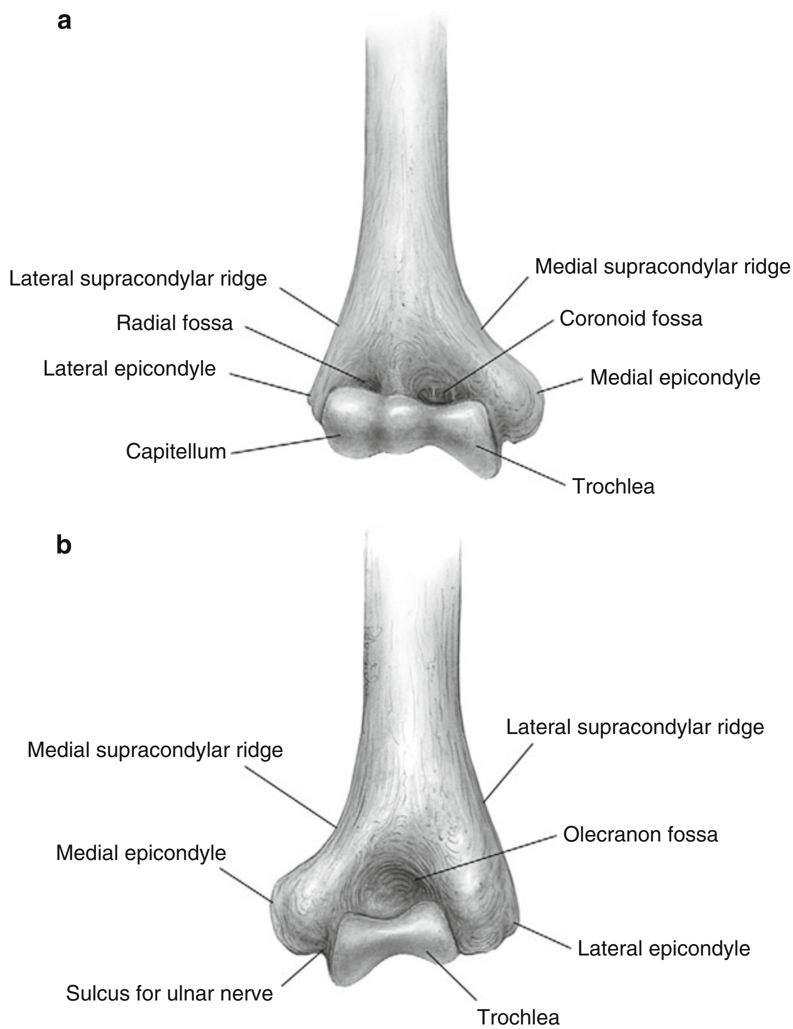

Fig. 1 Distal humerus osseous anatomy (Miyasaka [26])

when performing surgery with a minimalist dissection. To add to the confusion, the subtle bony protuberances of the lateral epicondyle are often highly variable and do not provide reliable landmarks for isometry.

The broad, rounded surface of the lateral epicondyle also provides additional challenges as to the type of reconstructions that can be performed. Surgical techniques utilized on the medial aspect of the elbow do not translate well on the lateral side. We have found that trying to create divergent tunnels into the broad lateral epicondyle is difficult to achieve while trying to maintain isometry and at the same time avoiding bony tunnel breakage.

Ligamentous Anatomy

The lateral collateral (radial) ligamentous complex runs from the lateral condyle of the humerus to the annular ligament with some fibers extending to the radial neck. The lateral collateral ligament complex consists of three components: the annular ligament, the radial collateral ligament, and the lateral ulnar collateral ligament.

The annular ligament almost completely surrounds the radial head, allowing radial rotation and stability of the radial head in the lesser sigmoid notch. The RCL is fan shaped and originates on the lateral epicondyle and inserts into and blends with the annular ligament. The LUCL

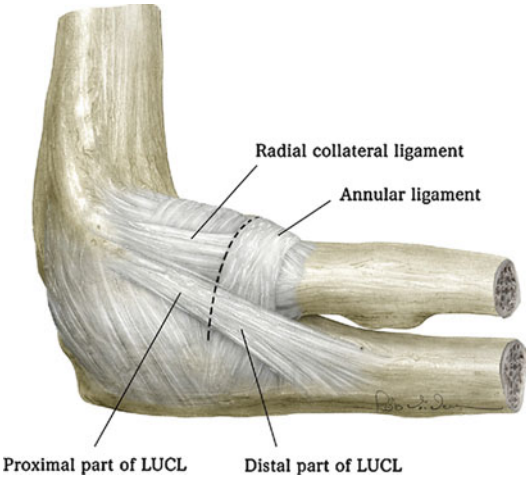

Fig. 2 Lateral elbow ligamentous anatomy: The lateral ulnar collateral ligament, annular ligament, and radial collateral ligament can all be seen. Additionally the undersurface attachment of the LUCL is seen (Lynch et al. [27])

originates from the lateral humeral epicondyle to insert on the tubercle of the supinator crest. As mentioned, the LUCL is a key component in preventing posterolateral and varus instability [1, 12].

The anterior aspect of the elbow capsule is thick and performs a role in affording stability against hyperextension of the elbow. The posterior capsule also has thickened bands that are often considered the posterior ligament.

Etiology

Injury to the LUCL can develop following an initially traumatic elbow dislocation or ligament sprain [1, 13, 14]. The injury spectrum spans from

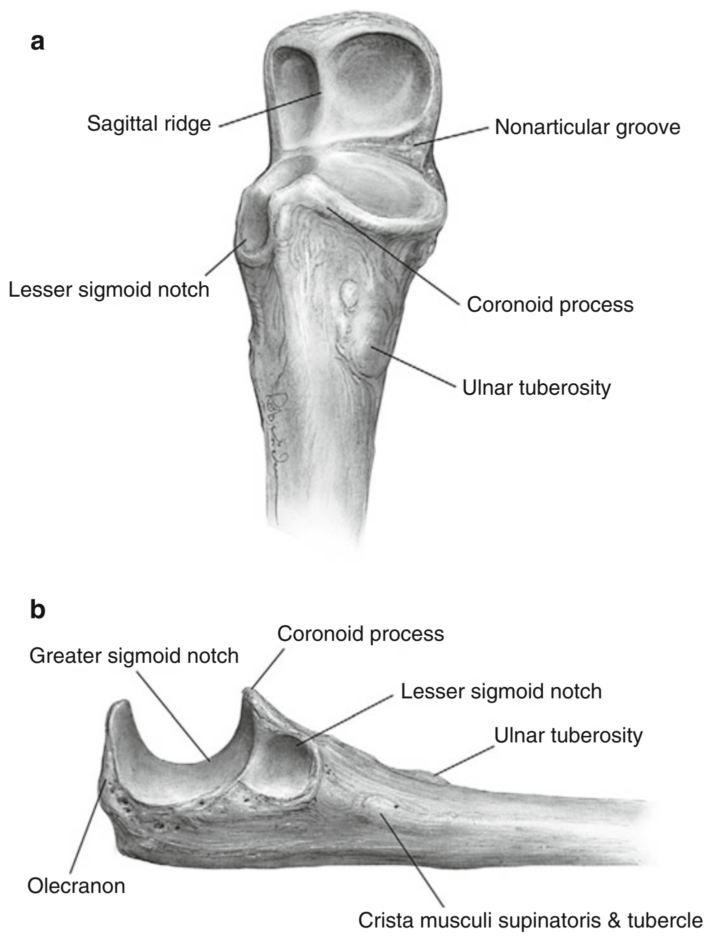

Fig. 3 Proximal ulna osseous anatomy (Miyasaka [26])

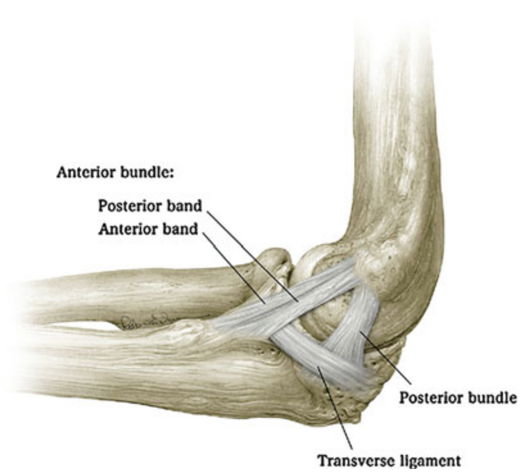

Fig. 4 Medial elbow ligamentous anatomy (Lynch et al. [27])

the clinically subtle entity of PLRI to the obvious fracture dislocation of the elbow or "terrible triad" injury. The mechanism of injury is commonly a fall on an outstretched and supinated hand. The typical injury pattern encountered is that the lateral ligament complex is avulsed off of the lateral epicondyle of the humerus.

Biomechanics

The LUCL serves as a checkrein in preventing excessive external rotation of the radius relative to the capitellum; therefore, injury allows for the ulna and radius to have excessive supination or external rotation about the humerus. This leads to a posterior instability of the radiocapitellar joint and can cause the radial head to subluxate posteriorly. There can also be subtle instability in the proximal radioulnar joint. With the LUCL injured, the annular ligament is the only ligamentous structure maintaining the radial head's position on the sigmoid notch. Secondary stabilizers also play an important role in stability; the radial head serves to tension the lateral ligaments and prevent posterior instability [15]. Additionally, overlying musculature serves a dynamic role in conferring medial elbow stability.

Patient Presentation

The typical presentation of individuals suffering from posterolateral instability has elbow locking, snapping, and subluxation that occur when the elbow is extended and the forearm supinated.

Physical Exam

The varus stress test is used in order to assess the radial collateral ligament. By placing the patient's arm in 20° of flexion and slight supination beyond neutral, the examiner then places one hand over the medial aspect of the distal humerus and the other hand lateral to the distal forearm. This is followed by a varus stress applied to the forearm with a concomitant counterforce placed upon the humerus. This will create excessive gapping on the lateral aspect of the elbow joint when compared to the contralateral arm [14, 16].

There are four common tests for posterolateral rotatory instability caused by incompetence of the lateral ulnar collateral ligament (LUCL). Tests for PRLI are often difficult to perform and interpret in an awake, alert patient due to the possibility of patient guarding. In order to limit patient apprehension, one of three techniques may be used: (1) intra-articular local anesthetic, (2) fluoroscopy to assess the radiocapitellar subluxation, or (3) the exam can be performed under sedation [17].

In his original description of PLRI, O'Driscoll [1] described the pivot-shift test for the elbow. The PLRI test or lateral pivot-shift test of the elbow is performed in the supine patient with the arm fully abducted and extended overhead. The examiner applies a valgus stress and axial load with the forearm supinated while the elbow is brought from extension to flexion. Occasionally, the radial head can appear prominent and dimple in extension. As the elbow is flexed, the radial head may reduce with a clunk, often at greater than 40 ° of flexion, or when awake, the patient feels apprehension as the radial head reduces (Fig. 5).

Another common test for PLRI is the posterolateral rotary drawer test (Fig. 6). In this test the patient is again supine with the arm overhead and

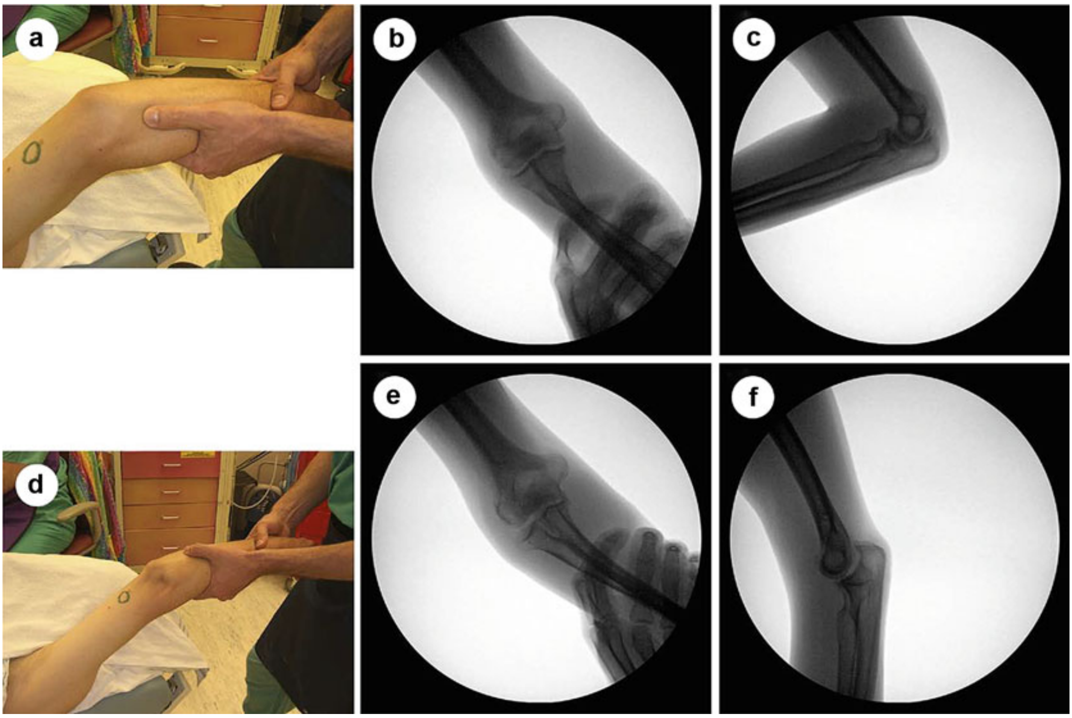

Fig. 5 The pivot-shift test for PLRI: Notice that this test can be performed under fluoroscopy to evaluate the degree of laxity (Sanchez-Sotelo et al. [7])

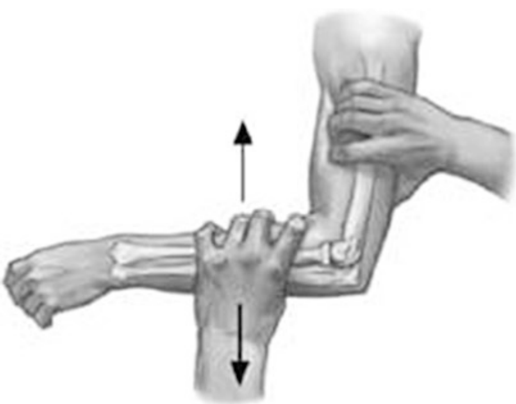

Fig. 6 The posterior drawer test for PLRI (Sanchez-Sotelo et al. [7])

Fig. 7 The push-up test (proprietary)

the elbow flexed from 40° to 90°. The examiner then, while stabilizing the humerus, applies posteromedial force on the radius attempting to get the radius and ulna to rotate around an intact ulnar collateral ligament and the radial head to subluxate posteriorly.

Two other described tests for PLRI are the push-up test (Fig. 7) and the stand-up test. In the push-up test, the patient starts in a prone position lying on the ground and attempts a push-up with the forearms maximally supinated and repeats a push-up with the forearms maximally pronated. If symptoms occur with the forearms supinated but not pronated, the test has a positive result. In the stand-up test, the patient attempts to get up from a seated position using his or her arms behind him to push with the forearms maximally supinated. A positive test result will reproduce the patient's symptoms.

In a prospective evaluation by Regan and Lapner of eight patients with PLRI, seven had both positive push-up and chair tests preoperatively and only 3/8 had positive pivot-shift or drawer tests while awake. Of note, under anesthesia, all eight patients had a positive drawer test [18].

Surgical Reconstruction

The variables in planning surgical reconstruction include graft choice, surgical technique, and postoperative rehabilitation protocol. Common graft choices include palmaris longus, semitendinosus, gracilis, and triceps aponeurosis [19, 20]. Either autograft or allografts can be utilized.

Nestor, O'Driscoll, and Morrey published the first series of surgical reconstruction of the LUCL in 1992 [4]. The article describes 11 patients who underwent reconstruction using Morrey's technique. A Kocher approach to the elbow is used with elevation of the common extensor origin and the internal between the anconeus and the extensor carpi ulnaris is developed in order to identify the ligament and the supinator crest. After identifying the isometry point on the lateral epicondyle, a single tunnel is created in the lateral epicondyle with a superior and inferior exit point in order to loop the tendon loops through the epicondyle. Converging tunnels are created in the supinator crest, and the tendon is tied to itself in a similar fashion to the original Jobe description of the elbow medial ulnar collateral ligament reconstruction [21].

Other methods of fixation have been described and utilized. Importantly, all are predicated on establishing the LUCL isometric point on the lateral epicondyle. A recent article by the senior author describes using the humeral center of rotation as the isometric point. In a cadaveric study, the humeral center of rotation, found on a perfect lateral radiograph, led to the smallest amount of graft elongation after loading. The humeral isometric point was also found to be more important than graft placement on the ulna for prevention of graft elongation [6] (Fig. 8).

Fig. 8 Humeral center of rotation (Alaia et al. [6])

Other common methods of fixation include suture anchor fixation, interference screw fixation, and a "docking" technique with humeral and ulnar bone tunnels [19, 22]. The author's preferred method of reconstruction focuses on utilizing the center of rotation of the humerus in order to obtain the most isometric graft. Because of the above-described bony anatomy of the lateral epicondyle, attempting to find the isometric point on lateral epicondyle can be frustrating unless done via radiographic means [6] (Fig. 9). The broad convex surface of the lateral epicondyle presents additional challenges to creating a suitably isometric graft when utilizing a reconstruction technique that mimics those that are done for the UCL of the elbow. Creating bone tunnels that enter the rounded lateral epicondyle tangential to the isometric point makes it difficult to obtain isometry reliably (Fig. 2). Additionally, because of this rounded surface, making bone tunnels in this area either risks breaking through the cortex or making an extensive dissection on the posterior aspect of the lateral epicondyle.

Currently we are utilizing a single-limb reconstruction of the LUCL with a tendon graft combined with a nonabsorbable tape, secured with a forked-tip interference screw fixation (Fig. 10).

Fig. 9 Radiographic humeral center of rotation (proprietary)

The LUCL does not exist as a double limb, and we feel that performing a single limb reconstruction is both sufficient and more anatomic then a double limb reconstruction in this way adds any benefit. The addition of a nonabsorbable tape provides initial stability and prevention of tendon graft elongation during its incorporation period. Its safety and efficacy have been supported in multiple other applications [23, 24].

After finding the center of rotation of the humerus via radiographic parameters, a guidewire is placed into the humerus center of rotation (Fig. 8) and drilled with a 5.5 mm cannulated reamer perpendicular to the surface of the lateral epicondyle (Fig. 11). While placement of the graft is not as crucial on the ulna side, we place a guidewire on the supinator crest in line with the midway point between the radial head articular surface and the radial neck. This is then drilled with a 5.0 mm cannulated drill (Fig. 12). Bone fragments are thoroughly irrigated out. A tendon graft (palmaris longus) along with a nonabsorbable tape is placed into the ulna hole and secured using a forked-tip interference screw technique. The tendon graft and tape are then dunked into the lateral epicondyle hole with a second forked-tip interference screw. The remaining tendon can then be cut off or sutured to the annular ligament in order to recreate the radial collateral ligament (Fig. 13). This represents a more minimally invasive way to reconstruct the LUCL as less tendons and soft tissue need to be stripped from the lateral epicondyle and ulna.

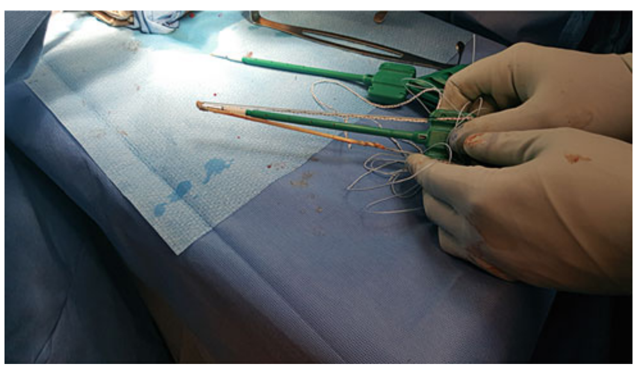

Fig. 10 Single-limb graft with nonabsorbable tape (proprietary)

The "terrible triad" is a combination of a coronoid fracture, radial head fracture, and elbow instability and bears mentioning here because the LUCL is typically involved first followed by UCL disruption. The treatment of the "terrible triad" typically involves fixing the coronoid fracture and repairing or replacing the radial head, the combination leading to a relatively extensive surgical morbidity and long operative time. Despite fixing both structures, there is often still gross elbow instability due to LUCL and UCL disruption. Because these ligaments are often torn and irreparable way, attempting to repair these ligaments is often not sufficient to confer elbow stability. In cases where the elbow is grossly unstable following ligamentous repair or reconstruction, a hinged external fixator to the elbow has traditionally been described to provide additional stability while allowing early motion to decrease postoperative stiffness [25]. The thought of now adding an external fixator at this time can seem not only daunting to the surgeon, but potentially harmful to the patient because of the increased surgical time, trauma, and a greater risk of infection.

Fig. 11 Lateral epicondyle reamed over guidewire with 5.5 mm reamer (proprietary)

A minimally invasive alternative to an external fixator is to employ our technique of using a forked-tip interference screw. We utilize only a nonabsorbable tape suture as an internal brace or an "internal external fixator." The only difference to the technique in using only a nonabsorbable tape, instead of a tape with a tendon graft, is that drill sizes will be proportionately smaller with only the tape.

Once the center of rotation on the humerus is determined, we have found that this technique requires no more than 10 min of additional operative time. Most often, doing this for the LUCL confers adequate stability to the elbow, obviating

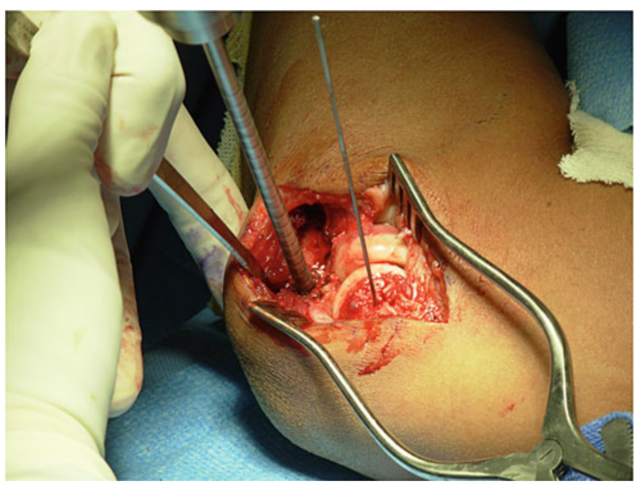

Fig. 12 Reaming 5 mm tunnel in the ulna (proprietary)

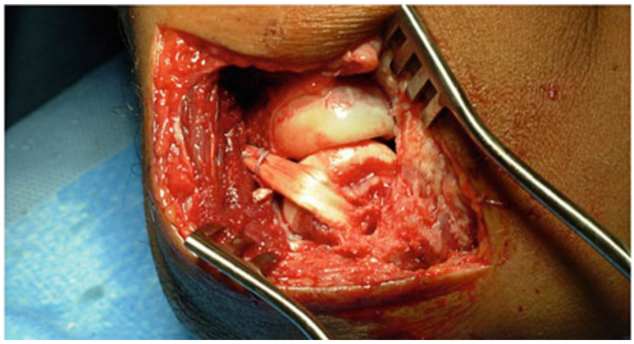

Fig. 13 Final single-limb construct (proprietary)

the need for an external fixator or reconstruction on the medial side of the elbow.

Typically, postoperative rehabilitation protocols are dictated by associated injuries and the amount of stability determined intraoperatively. In a simple LUCL disruption, the lateral structures are under maximal tension in extension and supination, while the extensor tendons that are repaired are under maximal tension with forearm pronation and wrist flexion. The rehabilitation protocols depend on what the surgeon feels the weakest link might be. Often what is of greater concern is the relative strength of the repair extensor tendons for which early elbow range of motion can be started in the range of 45–120 ° while in a hinged elbow brace and wrist immobilizer.

Summary

The LUCL entails complex anatomical features and injuries to it are relatively infrequent. Because of this, orthopedic surgeons can be less familiar with the anatomy; the concepts can be confusing and therefore can pose many potential challenges. Successful reconstruction of the LUCL is strongly tied with the knowledge of how to obtain the most isometry via the center of humeral rotation. We believe that utilizing more minimally invasive and surgical techniques to achieve stability provides significant functional benefits to patient throughout their treatment course.

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