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Hand Clin 24 (2008) 125–137

HAND
CLINICS

Essex-Lopresti Injuries

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The Essex-Lopresti injury, or longitudinal radioulnar dissociation, as originally described consists of (1) fracture of the radial head, (2) rupture of the interosseous membrane (IOM), and (3) disruption of the distal radioulnar joint (DRUJ) [1]. It is an injury that is typically difficult to diagnose and even harder to treat. Today, many experts believe there should be another component to an Essex-Lopresti injury: disruption of the triangular fibrocartilage complex (TFCC) [2,3]. Radioulnar dissociation is usually a result of a high-energy fall onto an outstretched hand, creating a longitudinal compression force on the wrist, forearm, and ultimately the elbow. Initially, attention by medical personnel is solely focused on the very painful and obvious radial head fracture on radiograph. In many cases, during the acute stages of the injury, the wrist and forearm are minimally tender and without swelling. Often, the radial head fracture provides sufficient elbow pain that patients are distracted from any symptoms in the forearm. In these severe injuries, however, the forearm is rendered unstable by the loss of continuity of the IOM. The radius migrates proximally, resulting in decreased motion, weakness, and increased forearm and wrist pain over time. The key to Essex-Lopresti injuries is early diagnosis because management is guided by the discovery of this injury.

History

The recognition of this injury has only been recent, having first been introduced into the literature by Curr and Coe [4] in 1946 and then again in 1951 by Essex-Lopresti [1], for whom this injury is named. His name is attached to this injury because he made many of the fundamental observations and conclusions regarding the clinical significance of longitudinal radioulnar dissociation through a series of case reports.

Essex-Lopresti (1916–1951) was trained at the London Hospital. He joined the Royal Army Medical Corps serving as a surgical specialist in an airborne division. As a result of this experience, he was able to give a comprehensive report on the injuries associated with 20,777 parachute jumps made by men in the Sixth British Airborne Division, one of the first such reports. At the end of World War II, he went back to the Birmingham Accident Hospital where he practiced as a surgeon and professor. It was at this point that his paper on radioulnar dislocation of the forearm was written. Essex-Lopresti was a talented and energetic young surgeon, whose death at the age of 35 cut short a promising career.

One of the observations in his paper was that the mechanism of injury involves a particularly violent longitudinal compression force with subsequent injury to the radial head, IOM, and DRUJ. He also recognized that wrist and forearm symptoms may not be present despite injury to wrist and forearm soft tissue structures. He further recommended performing an open reduction and internal fixation of the fracture if possible. He suggested that in this clinical scenario, the radial head should not be excised under any circumstance and that if comminution precludes fixation, a prosthetic radial head should be used [1]. These conclusions, made half a century ago, remain the principles that guide diagnosis and treatment today.

Anatomy

The IOM is a quadrangular sheath that extends from the radius to the ulna, filling the

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doi:10.1016/j.hcl.2007.11.009

space between and linking the two bones of the forearm. It separates the anterior and the posterior compartments of the forearm. Proximally and distally, the membrane is not continuous and is perforated by the posterior and anterior interosseous vessels. The membrane is arranged in a continuous fashion in the anterior plane and it is discontinuous in the posterior plane. It consists of a membranous portion, a central band, accessory bands, and a proximal interosseous band [5]. According to Poitevin [6], however, there are three anterior fibers that run distally at the junction of the proximal radius with the distal two thirds of the radius at an interosseous tubercle (Fig. 1). Here, the three fibers diverge as they run distally toward the ulna. These three fiber groups are (1) the proximal descending fibers, which run almost horizontal; (2) the intermediate descending fibers, which run in the short oblique direction (this is the "central band" fiber described by Skahen and colleagues [5] and Hotchkiss and colleagues [7]); and (3) the distal descending fibers, which run a long, oblique trajectory.

In the posterior plane, there are two fiber groups that run proximally and obliquely from the radius to the ulna. These two fiber bundles are (see Fig. 1) the proximal ascending bundle, which is short, oblique, and quite strong and originates at the interosseous tubercle, and the distal ascending bundle, which is inconstant. Its direction is long, oblique. It arises from the distal radius and reaches the proximal ulna.

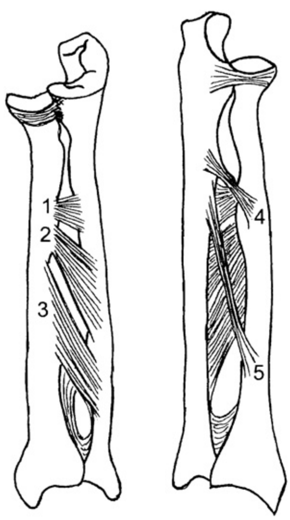

Fig. 1. The interosseous membrane has three volar bands (proximal descending fibers [1], intermediate descending fibers or "central band" [2], and distal descending fibers [3]) and two dorsal bands (proximal ascending bundle [4] and distal ascending bundle [5]). (*From* Poitevin LA. Anatomy and biomechanics of the interosseous membrane: its importance in the longitudinal stability of the forearm. Hand Clin 2001;17:99; with permission.)

Because of the obliquity of the attachment of these fibers, when the radius is distracted, the central bundles of the IOM relax. When the radius is axially loaded, these same bundles tighten. Poitevin [6] stresses that these particular fibers have not been emphasized in the literature and it is believed that any of the descending fibers alone could resist proximal migration of the radius and any of the ascending fibers alone could resist distal migration of the radius. The interosseous tubercle, where most of the fibers originate, is on the ulnar aspect of the radius, approximately 8 cm from the elbow joint. Poitevin [6] calls this tubercle "the assemblage nucleus of the IOM." The intermediate descending fibers (the "central band" in Skahen and coworkers' [5] description) and the proximal ascending bundle are the thickest and also the most constant structures found in the IOM. They both arise at the interosseous tubercle and form a structural dynamic unit of the forearm bones in pushing and pulling activities.

Other researchers have theorized several functions for the IOM [8–10]:

1. Force transfer from the radius to the ulna
2. Muscular origin for several flexor and extensor muscles
3. Maintenance of longitudinal and transverse forearm stability
4. Support during pronation and supination

In understanding the force transfer function of the IOM, consider that at the DRUJ, the radius bears about 80% of a compressive load and the ulna about 20%. At the proximal radioulnar joint, the radius bears about 60%, whereas the ulna now bears more at 40% [11]. These data imply that anatomically, the IOM is loaded under tension when the forearm is axially loaded. Conceivably, this distal to proximal load transfer from radius to ulna takes the burden off the proximal radius and radial head.

The muscular origins for the various muscles include [12]

1. Flexor digitorum profundus
2. Flexor pollicis longus
3. Extensor pollicis brevis
4. Abductor pollicis longus

5. Extensor indicis
6. Extensor pollicis longus

In the dissection of human cadaveric forearms, it was found that the central band (or intermediate descending fibers) of the IOM was the most dominant and consistent structure, whereas the proximal and distal ends of the IOM are thin and membranous [5]. The central band originates on the radius and inserts on the ulna and possesses a distinct oblique radioulnar direction of 21 degrees to the longitudinal axis of the ulna [5]. The average length of the radial origin and ulnar insertion of the central band have been found to be about the same at 10.6 cm. On the dorsal surface of the radius, the origin is broad and fan-shaped at the level of the abductor pollicis longus origin. Distally, it fades to the sharp interosseous border of the radius. On the palmar surface, the origin is also broad at the level of the flexor pollicis longus origin and gradually fades to the sharp interosseous border distally.

The bony attachment of the ulnar insertion of the IOM is quite different. The dorsal ulnar insertion is broad along the entire dorsal flat surface of the ulna; however, the palmar attachment is limited to the sharp interosseous border. Because the central band fibers tend to fan out as they pass from the radius to the ulna, the average radial origin measures 3.4 cm, whereas the ulnar insertion measures an average of 4.2 cm. The central band origin can be found at an average of 7.7 cm distal from the articular surface of the radial head. The average insertion point is 13.7 cm distal to the tip of the olecranon. The central band is in general two to three times thicker than the membranous portion [10].

The accessory bands were separate and distinct from the central band and not only were less substantial but they also varied in number and orientation among cadaveric specimens. The proximal interosseous band is found exclusively on the dorsal surface of the proximal forearm. Fibers of this band are oriented proximal and ulnar as they pass from the radius to the ulna. This structure shares a point of origin with the central band, although its fibers are oriented perpendicular to the central, an average of 28 degrees to the longitudinal axis of the ulna [5].

Histology

McGinley and colleagues [13] found that the IOM is primarily composed of collagen arranged in fibrillar structures surrounded by elastin. Collagen was abundant in the proximal bundles and decreased in the distal bundles. Histologic analysis of the IOM bundles obtained from cadaveric forearms showed that collagen represented greater than 90% of the central band.

Biomechanics

There are several levels of restraint against proximal migration of the radius. The primary restraint is that of the radius abutting the capitellum. It has been shown that the TFCC and IOM are the secondary restraints [2]. Wallace and colleagues [14] studied the structure and function of the IOM in 11 cadaver preparations. They made a model of longitudinal radioulnar dissociation by applying longitudinal tensile load until rupture of the IOM. Seven of the specimens sustained a midsubstance tear of the central band of the IOM at a mean peak load of 1038 N [14]. Hotchkiss and colleagues [7] found that the central band portion of the IOM was responsible for 71% of the total longitudinal stiffness of the IOM after radial head excision.

Other authors have shown that varus-valgus moments about the elbow, caused by transverse loads applied at the hand in intact specimens, affect the magnitude of IOM load transfer [15,16]. Interosseous ligament load transfer was found to be consistently lower when the elbow experienced a valgus stress compared with a varus stress under an axially applied load to the hand of 134 N [15].

Several studies have examined the strain and load distribution of the IOM in relation to forearm rotation. Pfaeffle and colleagues [17] measured three-dimensional force vectors acting in the forearm when axially loaded to 136 N in intact specimens. They showed that the IOM participates not only in longitudinal load transfer, but also in the maintenance of transverse stability of the forearm. Forces in the IOM were significantly greater in neutral rotation compared with supination or pronation. Manson and colleagues [18] studied five intact cadaveric forearms and found that the strain distribution of the IOM changed with forearm rotation, again with the highest overall strain in neutral rotation. In neutral and pronation, higher strain was observed in the proximal region of the IOM. In supination, however, higher average strain was seen in the distal region of the IOM.

As Manson and colleagues [18] noted, these findings may be helpful in answering questions of optimal placement of a reconstructive graft and the ideal rotational position of the forearm during graft tensioning. For example, the results suggest that to provide balanced constraint in different positions of forearm rotation, the ideal placement of a graft is in the proximal region of the IOM and tensioned in neutral rotation [18,19].

After radial head excision in cadavers, Rabinowitz and colleagues [20] and Skahen and colleagues [5] demonstrated not only substantially more strain in the IOM, but also increasing strain in the IOM as the forearm was rotated from supination to pronation (Fig. 2). These findings confirm the IOM's secondary role in maintaining dynamic radioulnar stability when changes to radial length occur.

Clinical presentation

An Essex-Lopresti injury is usually sustained during a high-energy axial load onto an outstretched hand. As such, a longitudinal force is transmitted through the wrist to the radial head. When increasingly sufficient force is exerted, the head of the radius fractures or dislocates, the IOM ruptures, and the DRUJ ruptures. Consequently, the radius migrates proximally, leaving the patient with complex instability of the forearm. Patients complain of elbow and wrist pain. Some may also be acutely aware of pain throughout the forearm.

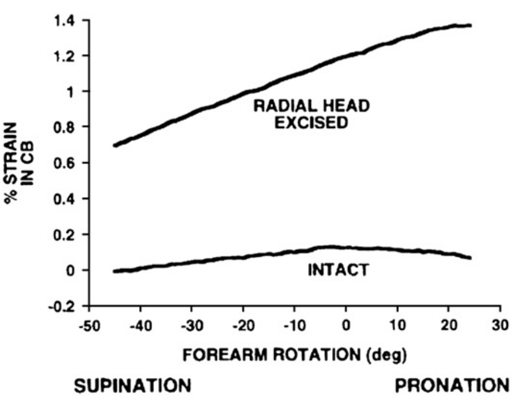

Fig. 2. This graph demonstrates the percentage strain withstood by the central band with an intact radial head compared with the increased strain after radial head excision in cadaveric biomechanical testing. (*From* Skahen JR III, Palmer AK, Werner FW, et al. The interosseous membrane of the forearm: anatomy and function. J Hand Surg [Am] 1997;22:985; with permission.)

Physical examination often yields ulnar-sided wrist tenderness with increasing pain as the forearm is rotated. The forearm itself may be tender and ecchymotic, especially between the radius and ulna in the interosseous space. Examination of the elbow may demonstrate lateral ecchymosis and tenderness. Attention must focus on the elbow, forearm, and wrist to diagnose accurately this disruption of the forearm "ring."

The position of the forearm at the time of impact greatly influences the kind of fracture that results. Through a cadaveric forearm axial loading model, McGinley and colleagues [21] found that loading in supination produced both bone forearm fractures, loading in a neutral position resulted in isolated radial head fractures, and loading in pronation resulted in Essex-Lopresti injuries. In supination, there is the least amount of contact within the radiocapitellar joint and maximum tension within the IOM. Following sudden impact loading, forces are primarily transmitted from the radius through the IOM onto the ulna without being transmitted to the radiocapitellar joint. The large magnitude of the sudden load results in fractures of the radial and ulnar shafts without injury of the radial head.

In neutral position, there is moderate contact within the radiocapitellar joint and moderate tension in the IOM. As a result, the impact is primarily absorbed by the radial head but also reduced by transfer across the IOM, resulting in isolated marginal radial head fractures. In the pronated position, there is the most contact between the radial head and capitellum and very little tension in the IOM. All of the force of the impact is transferred onto the radial head, usually comminuting the head. This results in a shift or migration of the radius and subsequent tearing of the IOM [8,21–23]. With this knowledge in hand, the astute clinician knows when to suspect an Essex-Lopresti lesion, especially if comminution of the radial head is seen or if the clinical history suggests that the forearm was loaded in pronation at the time of injury.

It should be noted that subtle proximal migration of the radius (approximately 2–3 mm) usually occurs after fracture or excision of the radial head, but it is rarely symptomatic [10]. When both the primary and secondary stabilizers of the forearm are disrupted, however, proximal migration of the radial head usually averages greater than 7 mm, in which case patients become symptomatic by complaining of loss of wrist extension, forearm rotation, ulnocarpal impaction symptoms, and wrist pain. One study showed that patients with proximal radial translation greater than 1 cm usually experienced pain and loss of motion, whereas patients with translation less than 1 cm report pain but retain motion [24]. With the relative shortening of the radius compared with the ulna, the distal ulna loses its position in the sigmoid notch and actually becomes dorsally positioned in relation to the carpus. Supination and wrist extension are limited as the ulnar head comes into contact with the dorsal carpus. In addition to the wrist symptoms, the proximally migrating radius abuts the capitellum, leading to elbow pain and limitation of elbow motion.

An Essex-Lopresti injury of the forearm often is missed during assessment at the time of injury. A fracture of the radial head usually is apparent, whereas injury to the IOM and TFCC is not symptomatic in many patients at initial presentation. This is where the clinician must obtain a good history and have a high index of suspicion based on the mechanism of injury. Whenever a high-energy longitudinal compression force occurs (ie, fall from a height and motorcycle injuries), the Essex-Lopresti injury must be entertained.

Diagnostic imaging

Radiographs of the elbow, forearm, and wrist should be obtained when clinical suspicion is high for an Essex-Lopresti injury. It may also be helpful to obtain contralateral wrist films to have a baseline for comparison of ulnar variance. According to Epner and colleagues [25], the optimal view of the DRUJ is obtained using a posteroanterior radiograph with the shoulder at 90 degrees of abduction, the elbow flexed at 90 degrees, and the forearm in neutral rotation. According to Yeh and colleagues [26], however, ulnar variance can be assessed adequately with a routine posteroanterior radiograph of the wrist. Interestingly, Tomaino [27] took radiographs of the forearm while the patient was gripping to assess the change in ulnar variance and thereby indirectly evaluating for alterations in the integrity of the IOM. Although the posteroanterior view of the wrist may show a markedly positive ulnar variance, the lateral radiograph of the wrist is also helpful in assessing dorsal or volar subluxation of the ulna.

Biplanar radiographs of the forearm rule out diaphyseal fractures. Elbow radiographs often show a radial head or neck fracture with or without dislocation at the radiocapitellar joint, usually with comminution. A CT scan (with three-dimensional reconstructions) of the elbow may be helpful in determining the degree of comminution and articular involvement of the radial head.

Ultrasound, CT, and MRI are not typically used in diagnosing the soft tissue components of radioulnar dissociation. Failla and colleagues [28] used ultrasound to detect tears in the IOM in one living and two cadaveric forearms. In their study, the IOM is a very hyperechoic structure, with the central third of the IOM seen as a thick, continuous white line. It is the only continuous and intensely hyperechoic structure that connects the ulna to the radius. Any disruptions of the IOM show a break in this continuity of the white line representing the IOM. Wallace [29] described the ultrasound technique as one using a high-resolution dynamic machine with the transducer over the dorsal aspect of the forearm oriented transversely. Jaakkola and colleagues [30] also looked at the accuracy of ultrasound in detecting IOM disruptions and found a 96% accuracy rate when looking at cadaveric forearms. The sonographic criterion used to determine IOM disruption during the dynamic study was lack of visualization of a continuous hyperechoic band passing between the radius and ulna through a region of at least 2 cm in length. Matsuoka and colleagues [31] took it one step further and showed the accuracy of ultrasonography on living patients with and without the injury. IOM disruptions were seen as hypoechoic regions in longitudinal and transverse views.

In a study by McGinley and colleagues [32], MRI determination of IOM injury demonstrated a positive predictive value of 100%, a negative predictive value of 89%, a sensitivity of 87.5%, and a specificity of 100%. Further, they demonstrated that most lesions occurred along the IOM's ulnar insertion, and in half of the injured specimens there was concomitant dorsal oblique bundle disruption [32]. Sowa and colleagues [3] used MRI (specifically 1.6-T magnetic resonance with a wrist coil) to diagnose a tear in the central band of the IOM in one patient. Starch and Dabezies [33] concluded through cadaveric and live patient investigation that the IOM can be evaluated best by axial T2-weighted fast spin echo images with fat suppression.

Whereas the ultrasound and MRI studies mentioned previously focused on the integrity of the central third of the IOM, Soubeyrand and colleagues [34] found that a "muscular hernia sign" could be elicited anywhere along the IOM by directing an anteroposterior load on the anterior aspect of the forearm at a specific level, and if the IOM was not intact at that level, anterior musculature could be visualized by ultrasound on the posterior aspect of the forearm. CT, a modality more suited for evaluating bony anatomy and generally not useful in assessing IOM integrity, can be used to assess DRUJ reduction.

Treatment

Although it may be easy to separate the components of the injury into a fractured radial head, torn IOM, and disrupted DRUJ, it is essential to consider the injury as a disruption of the forearm "joint." Treatment of the radial head fracture alone may lead to persistent problems at the DRUJ. Healing and recovery depends on the management of both the elbow and the wrist (Figs. 3–7).

Every effort should be made to save the native radial head. If an open reduction and internal fixation cannot be achieved, then prosthetic replacement should be considered. When the DRUJ is dislocated in an Essex-Lopresti injury, some surgeons have advocated pinning or temporary syndesmotic screw placement between the radius and ulna to allow healing of the IOM and distal and proximal radioulnar ligaments. In theory, stabilization of the forearm using screws or wires allows healing of the soft tissue structures to occur. There is not clear evidence, however, that when the IOM is immobilized by syndesmotic screw fixation, it always heals [7].

Radial head excision alone leads to suboptimal results. In one study, 15 of the 20 patients reported severe pain at the DRUJ when the radial head was excised [35]. Radial head allografts have also not been very successful in restoring forearm stability [36]. Silicone prostheses have been associated with gradual material failure and continued proximal migration [37–40]. Currently, there are a number of metallic radial head prostheses available with different implant styles that cater to the surgical approach and character of the radial head and neck fracture.

Central band repair and reconstruction has been tried by many authors, all in limited numbers with brief follow-up. Augmentation tissues have included flexor carpi ulnaris tendon, palmaris longus tendon, tibia-fibula interosseous ligament bone-ligament bone-autograft, and bone-ligament-bone allograft. Conversion to a one-bone forearm is the ultimate salvage alternative in patients with chronic, symptomatic longitudinal forearm instability. It has been met with the most success in treating these patients [41]. It is associated with loss of rotation, however, and recent studies have called into question previous favorable results [42].

Acceptable outcomes in the treatment of acute radioulnar dissociation are incumbent on

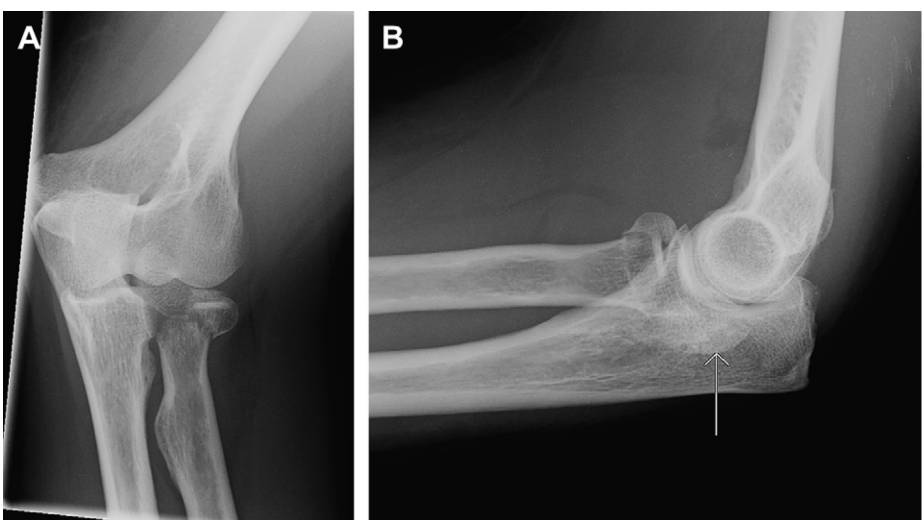

Fig. 3. (*A*) Anteroposterior radiograph of an Essex-Lopresti injury demonstrating a comminuted radial head fracture. (*B*) On the lateral view, an arrow points out a malrotated and displaced articular fragment. This patient presented with elbow, forearm, and wrist pain.

Fig. 4. (*A*) The same patient's posteroanterior radiograph of the wrist revealed subtle widening at the DRUJ. (*B*) The lateral wrist radiograph confirmed dorsal subluxation of the distal ulna.

maintenance of forearm length. Forearm length is dependent on preservation or replacement of the radial head and repair of the TFCC. Stabilization and repair of these two structures are sufficient to restore longitudinal stability of the forearm such that direct open repair or reconstruction of the IOM central band is not needed. In general, treatment of radioulnar dissociation is more effective when the diagnosis is made within the first week of injury. Indications for radial head fracture repair are the same as those used to treat isolated radial head fractures.

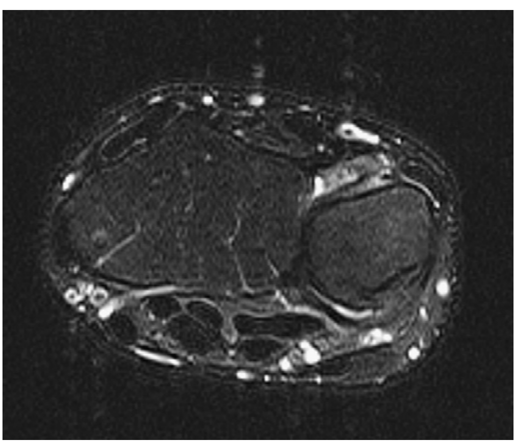

Fig. 5. MRI of the wrist demonstrated a dorsal distal radioulnar ligament avulsion from the distal radius with an intact triangular fibrocartilage.

Surgical management of acute injury

The technique outlined here is for acute injuries and it is based on the assumption that stabilizing the radial head and DRUJ is sufficient in restoring radioulnar stability. The most important aspect of preoperative planning is to ensure that the correct diagnosis has been made and that all of the necessary equipment is available for surgery. Equipment required intraoperatively includes the following:

Hand table
Fluoroscopy
Drill and wire driver
Micro sagittal saw
Kirschner wires
Suture anchors (regular and mini)
Radial head internal fixation
Radial head arthroplasty

Surgical approaches

It is the authors' preference to position the patient supine on the operative table with the affected arm draped free on a radiolucent hand table. An upper arm sterile tourniquet can be applied, if needed. Because Essex-Lopresti injuries are high energy and have associated soft tissue swelling, judicious tourniquet use should be with caution. With the limb draped free on the hand table, the entire elbow, forearm, and wrist may be

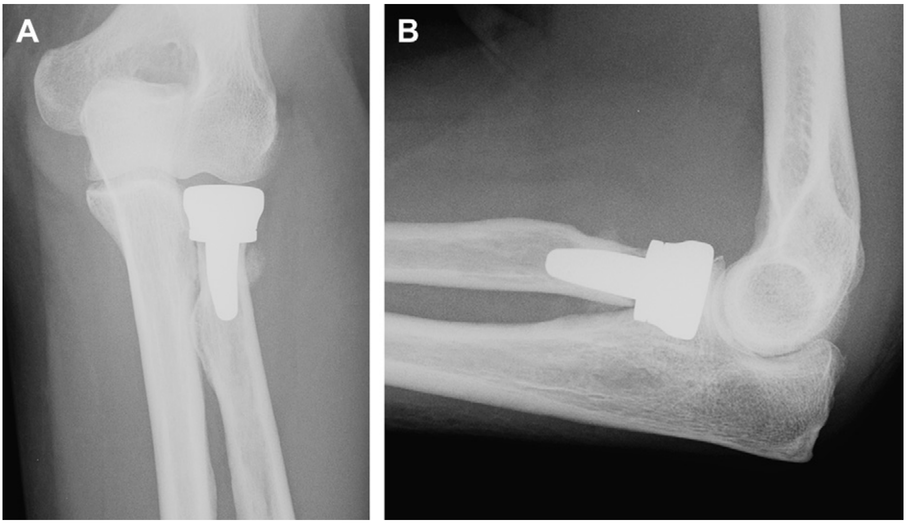

Fig. 6. Postoperative anteroposterior (*A*) and lateral (*B*) views after radial head replacement.

manipulated comfortably and may be exposed medially or laterally, as needed.

The radial head can be approached in a number of different ways, but it is the authors' preference to use a lateral approach between the extensor carpi radialis longus and extensor digitorum comminis (Fig. 8) [43]. This slightly more proximal approach to the radial head avoids inadvertent injury to the lateral collateral ligament and it allows for easier identification of the posterior interosseous nerve at the arcade of Frohse. A Kocher approach (between the anconeus and extensor carpi ulnaris) may also be used to approach the radial head [43].

After identification of the common extensor musculature, the fascia overlying the extensor carpi radialis longus and extensor digitorum comminis is incised (see Fig. 3). The extensor carpi radialis brevis (ECRB) should be visualized deep to these muscles at this point. Next, the ECRB

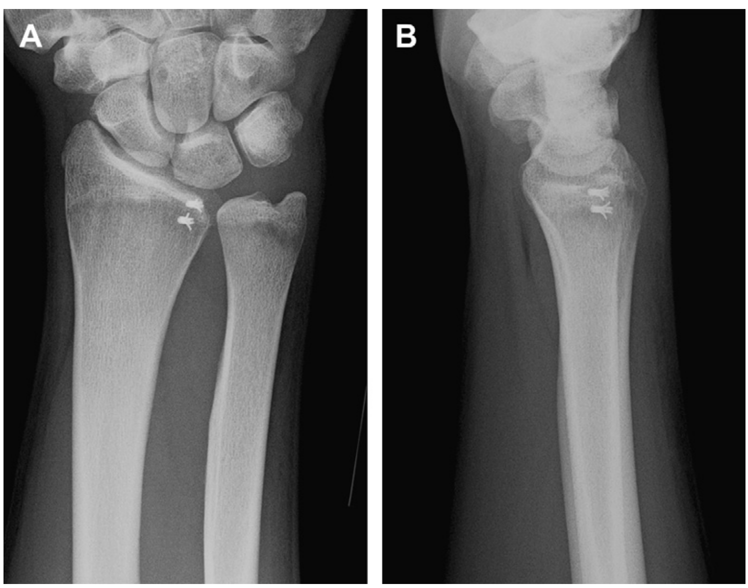

Fig. 7. (*A*) Repair of the ruptured dorsal distal radioulnar ligaments was performed with two suture anchors into the distal radius. (*B*) The lateral radiograph reveals a concentrically reduced DRUJ.

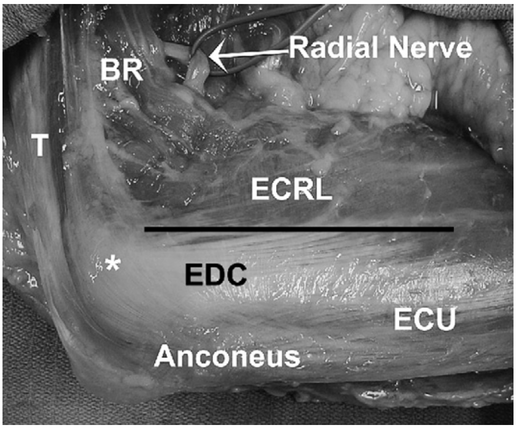

Fig. 8. This cadaveric dissection demonstrates a lateral approach to the radial head and radiocapitellar joint between the extensor digitorum communis (*black line*). Proximal to the traditional extensor carpi ulnaris-anconeus approach, this approach allows excellent access to the radial head without releasing the ulnar band of the lateral collateral ligament.

and extensor carpi radialis longus are retracted superiorly and the extensor digitorum comminis, inferiorly. At this juncture, the radial head should be palpable and identifiable underneath the capsule. The capsule can then be incised longitudinally under direct visualization. An attempt should be made to identify the posterior interosseous nerve with ulnar dissection in the interval between the supinator (deep) and the extensor carpi radialis longus and ECRB (superficial) to ensure its continuity. Identification of the posterior interosseous nerve as it enters the arcade of Frohse ensures its protection during internal fixation or arthroplasty of the radial head. Forearm pronation helps move the posterior interosseous nerve away from the lateral approach of the radial head and neck.

After the radial head and neck fractures have been repaired or replaced, it is important to ensure elbow stability and range of motion by testing these parameters with fluoroscopy while still in the operating room. Care should be taken to restore radial length. Radial length should be confirmed by fluoroscopic imaging of the wrist and comparing the restored radial height with that found on radiographs of the contralateral wrist. An anteroposterior view of the contralateral elbow may also be used in comparison to judge radial neck length and avoid "overstuffing" the radiocapitellar joint. Once the radial head implant is secured into place, any associated soft tissue disruptions should be repaired at this point (eg, the lateral collateral ligament).

Next, the DRUJ is addressed. In cases where DRUJ injury is equivocal, ligamentous stress testing done in the operating room at this point should be done to determine if surgical intervention is required. Smith and colleagues [44] describe a "radius pull test" as a stress test in the operating room to determine longitudinal radioulnar stability. The patient lays supine, shoulder abducted to 90 degrees and internally rotated so that the extremity lies flat on the table. The elbow is flexed to 90 degrees, and the forearm and wrist are placed in neutral rotation. A bone-reduction tenaculum is then used to grasp the proximal part of the radius and a longitudinal pull of approximately 20 lb is applied manually in line with the radius. Fluoroscopy is used to measure ulnar variance and proximal radial migration.

Lastly, the DRUJ dorsal and volar ligaments along with the TFCC are stressed with dorsal and volar translation between the distal radius and distal ulna with the forearm in neutral, pronation, and supination. A solid end point should be present in all positions, if the joint is stable. It is helpful to have examined the contralateral wrist while the patient is under anesthesia to understand better a stable versus unstable DRUJ in each patient. If there is significant subluxation in pronation and supination, operative treatment is warranted.

It is possible for the DRUJ to be stable in one position, but unstable in another. For example, if the DRUJ dorsally subluxates in pronation but is stable in supination, the forearm may be immobilized in a supinated position until there is ligamentous healing at the DRUJ. It is the authors' preference to stabilize the DRUJ operatively if it is acutely unstable, because prolonged immobilization after radial head repair or arthroplasty inevitably leads to stiffness.

The TFCC may be inspected in an arthroscopic or open fashion. Arthroscopy of the radiocarpal joint alone is not sufficient, especially if the meniscal homolog of the TFCC is intact. In these high-energy injuries, the TFCC is often torn at its insertion on the ulnar fovea, which is readily visible during DRUJ arthroscopy but only visible from the radiocarpal joint if there is a large tear through the meniscal homolog of the TFCC.

When the TFCC insertion has been disrupted, direct repair of the TFCC should be considered. The DRUJ may be approached through the interval between the fourth and fifth dorsal compartments. The extensor retinaculum is incised longitudinally and the fourth dorsal compartment elevated subperiosteally and retracted radially. The extensor digiti quinti minimi is retracted ulnarly. Careful examination of the dorsal joint may reveal capsular avulsion with or without disruption of the dorsal distal radioulnar ligament. If inspection of the TFCC reveals injury of its insertion into the ulnar fovea, this tissue is reattached with suture anchors or through small bone tunnels.

There may be cases of continued DRUJ instability after repair of the TFCC insertion and supporting capsular structures. In these cases, reconstruction of the dorsal and volar DRUJ ligaments may be undertaken with a palmaris longus autograft or allograft tendon. Fractures of the ulnar styloid require reduction and repair with internal fixation if the DRUJ is unstable. The distal forearm may be pinned with 0.062-in Kirschner wires to protect the soft tissue repairs or as an alternative to direct repair. Two Kirschner wires are used and placed proximal to the DRUJ articular surfaces; these pins should be prominent radially and ulnarly to facilitate removal if they break.

Postoperative immobilization and rehabilitation

The patient should be initially immobilized in a well-padded and well-molded long posterior splint that extends to the distal palmar crease to immobilize the wrist. Patient's limb is mobilized depending on the patient's injury and the stability achieved intraoperatively. If Kirschner wires were used to stabilize the DRUJ, these should be removed at 8 to 10 weeks postoperatively as the patient is allowed full range of motion. Radiographs should be obtained in the immediate postoperative period to ensure that the radial head implant is reduced and secure.

Surgical management of chronic injuries

Several cadaveric studies show that restoration of forearm mechanics can be obtained with reconstruction of the IOM by various tendon grafts when the radial head is intact [17,19,45,46]. One such study includes the use of the palmaris longus or half of the flexor carpi radialis tendon [19]. Poitevin [6] advocates the use of an extensor indicis proprius transfer to the proximal radius, following the direction of the intermediate descending fibers. A double flexor carpi radialis weave is an alternative approach that provides mechanics across the distal and proximal radius equal to the intact IOM. Sellman and colleagues [45] further demonstrated the use of nylon rope to perform a flexible IOM reconstruction and found the construct to restore stiffness but only when the radiocapitellar articulation was restored. Marcotte and Osterman [47] describe a bone-ligament-bone reconstruction of delayed longitudinal radioulnar instability. Using

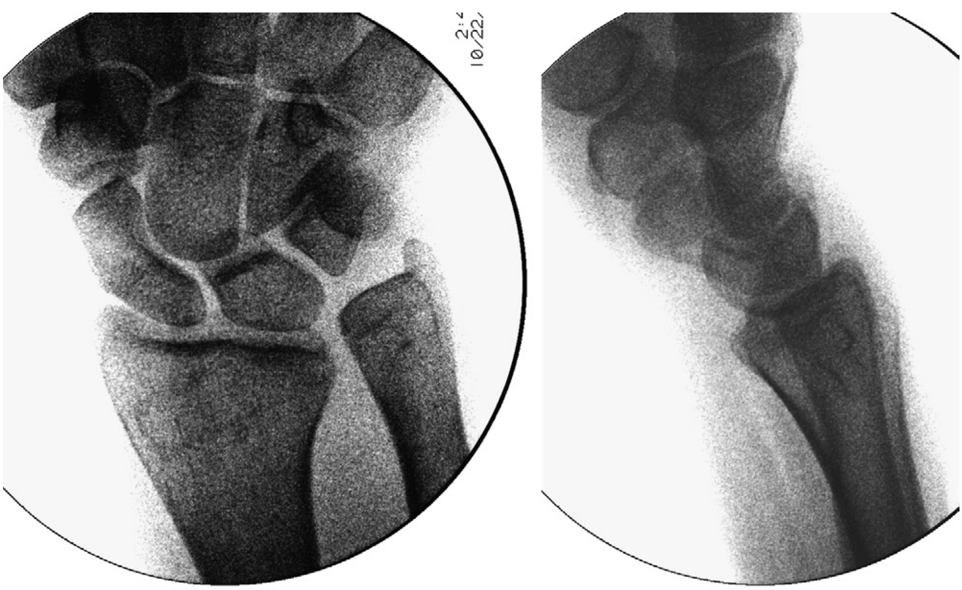

Fig. 9. Preoperative radiographs of a chronically unstable DRUJ after radial head resection for a congenitally dislocated radial head with deformity of the distal ulna. (*Courtesy of* Joseph F. Slade III, MD, New Haven, CT.)

Fig. 10. Postoperative fluoroscopic views of a semiconstrained DRUJ arthroplasty performed after radial head replacement. The ulnar positive height and distal ulnar instability have been corrected. (*Courtesy of* Joseph F. Slade III, MD, New Haven, CT.)

a bone-patellar tendon-bone autograft or allograft, the IOM has been reconstructed to restore longitudinal stability of the forearm [47]. Conversion of the injured forearm to a one-bone forearm remains a final salvage option for chronic cases that cannot be reconstructed.

The authors' preferred management of delayed presentation Essex-Lopresti injuries is typically staged. In the absence of capitellar degeneration, the radiocapitellar joint is first reconstructed with a radial head replacement. Combined radiocapitellar resurfacing is available for degeneration affecting both sides of the joint, but there are no peer reviewed results of this procedure to date. A period of interval healing after radial head replacement allows for the soft tissues to readjust to the lengthened radial height and allows for any settling of the new radial head. In addition, it minimizes painful overloading of the capitellar articular surface that could occur with a simultaneous ulnar shortening osteotomy and radial head arthroplasty.

If there are continued symptoms of forearm or wrist pain and dysfunction, the DRUJ is then reevaluated with comparison radiographs from the contralateral wrist. If there is no instability, but positive ulnar variance, then an ulnar shortening osteotomy is recommended. If there is instability at the DRUJ, then the ulnar shortening may need to be accompanied by a dorsal and volar DRUJ ligament reconstruction as suggested by Adams and Berger [48]. If the DRUJ has become arthritic, a distal ulna resection, hemiarthroplasty, or arthroplasty may be warranted to treat the articular pathology simultaneously with a correction of ulnar height. Semiconstrained arthroplasty of the DRUJ after radial head replacement is another possibility that may hold promise for challenging cases of chronic DRUJ instability (Figs. 9 and 10).

Summary

The Essex-Lopresti injury results from a high-energy trauma, causing significant instability to the forearm joint. The radial head is fractured, the IOM is torn, and the DRUJ is disrupted. The greatest challenge with this specific injury pattern is the diagnosis, because it is frequently missed in the emergency room. Once the diagnosis has been established, surgical treatment focuses on the elbow (radial head fracture) and the wrist (DRUJ disruption) to restore forearm length and stability. Chronic or untreated Essex-Lopresti lesions continue to challenge treating physicians and often require salvage or reconstructive procedures to minimize pain and return function.

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