JBJS ESSENTIAL Surgical Techniques

Crista Supinatoris Fractures of the Proximal Part of the Ulna

Surgical Technique

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Based on an original article: *J Bone Joint Surg Am*. 2014 Feb 19;96(4):326-31.

Introduction

Open reduction and internal fixation of crista supinatoris fractures is required when the elbow is unstable despite appropriate nonoperative management and when a patient is undergoing surgical treatment of a periarticular elbow fracture-dislocation.

The lateral collateral ligament of the elbow is composed of the lateral ulnar collateral ligament, the radial collateral ligament, and the annular ligament. Fractures of the crista supinatoris (Figs. 1-A and 1-B) indicate partial or complete disruption of the lateral ulnar collateral ligament at its ulnar attachment. Disruption of the lateral collateral ligament is commonly encountered in the setting of an elbow dislocation. In a consecutive series of ten simple elbow dislocations and fifty-two complex elbow fracture-dislocations, McKee et al.[1] identified disruption of the lateral collateral ligament in all patients. The two most frequently seen patterns of injury were proximal avulsion of the lateral collateral ligament (52% of the injuries) and midsubstance rupture of the lateral collateral ligament (29%). Osseous avulsion of the crista supinatoris was identified in one patient in that series. Recognition of this newly described injury pattern is important as it indicates partial or complete disruption of the lateral ulnar collateral ligament at its distal insertion (Figs. 1-A and 1-B).

Standard radiographs of the elbow often are not sufficient to identify and characterize crista supinatoris fractures (Figs. 2-A, 2-B, and 2-C). External oblique radiographs and computed tomography (CT) scans should be considered when evaluating complex elbow injuries to recognize this injury pattern. The external oblique view of the elbow is performed in the same manner as a standard anteroposterior view with the entire arm rotated externally by 45°.

To our knowledge, our previously published report[2] was the first to present the clinical and radiographic outcomes of a series of crista supinatoris fractures of the ulna managed either operatively or nonoperatively. The management of crista supinatoris fractures depends on elbow stability following the operative or nonoperative treatment of the associated periarticular elbow injuries. When patients are treated nonoperatively, evident lateral instability following a period of immobilization or after initiation of an early range-of-motion rehabilitation program indicates the need for surgical fixation. Nonoperatively treated patients are normally seen seven to ten days following the injury, at which point they are more comfortable and able to tolerate a more thorough assessment. Once muscle tone has returned and swelling is reduced, congruency of the elbow is assessed clinically and fluoroscopically to look for lateral-sided instability (see Step 3 below). Weekly clinical and radiographic follow-up is performed for the first four weeks to confirm maintenance of elbow stability and alignment and to rule out displacement of associated fractures. Although we do not have experience with delayed fixation of crista supinatoris fractures following failed nonoperative management, the approach to fracture reduction and fixation would be similar to that described below.

Patients who undergo surgical management of associated injuries (displaced radial head fracture, coronoid fracture, and/or distal humeral articular shear fracture) must be examined for lateral-sided instability (see Step 3 below). If lateral-sided instability persists, the crista supinatoris fracture should be addressed. Our technique for open reduction and internal fixation of crista supinatoris fractures (Video 1) involves the following steps.

Step 1: Skin Incision and Surgical Approach

Use a posterior or lateral skin incision according to your preference and then utilize the Kocher interval to access the joint, lateral collateral ligament, and crista supinatoris or, in the setting of a proximal ulnar fracture, use the Boyd interval.

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

- Position the patient supine with the arm supported on an arm table or placed across the chest to allow medial, lateral, and posterior access to the elbow.
- Apply a sterile pneumatic tourniquet.
- The location of the skin incision is based on the injury pattern in association with the crista supinatoris fracture and on the surgeon's preference. Typically, if a medial approach is required (in the presence of an anteromedial facet coronoid fracture or ulnar nerve symptoms, for example), we prefer to use a utilitarian posterior skin incision. However, using separate medial and lateral incisions is also quite acceptable. In the setting of an associated radial head fracture with or without a coronoid fracture, a single lateral incision is adequate since those structures are well visualized through a lateral-based approach[3].
- The posterior skin incision allows access to the medial and lateral aspects of the elbow through the creation of fasciocutaneous flaps. Furthermore, the cutaneous nerves are less at risk when this incision is used. However, creation of large skin flaps increases the risk of hematoma and seroma formation, and flap necrosis is a potential serious complication.

Kocher Interval

- Use the Kocher interval between the anconeus and the extensor carpi ulnaris to access the crista supinatoris fracture.
- Elevate the extensor carpi ulnaris anteriorly to visualize the lateral epicondyle, the lateral collateral ligament, and the crista supinatoris (Figs. 3-A and 3-B). Sharp dissection through the extensor carpi ulnaris fascia is often required to allow anterior retraction of its muscle belly.
- In the presence of a crista supinatoris fracture, the humeral origin and midsubstance of the lateral collateral ligament are typically intact and therefore should not be disrupted during the deep surgical exposure.

Boyd Interval

- When a proximal ulnar fracture requires fixation in the setting of a transolecranon elbow fracture-dislocation or Monteggia fracture, expose the crista supinatoris fracture through the Boyd interval.
- Elevate the anconeus from its ulnar insertion and retract its muscle belly laterally.
- In most cases, minimal sharp dissection is required to mobilize the anconeus, which is usually partially torn from the ulnar border as part of the associated soft-tissue injury (Fig. 4).
- Avoid devitalizing comminuted ulnar cortical fragments that remain attached to the anconeus. Instead, temporarily retract these fragments laterally, along with the anconeus muscle belly.
- The crista supinatoris fragment is deep to the supinator, which should be partially elevated to adequately visualize the crista supinatoris fragment (see Step 4 below).

Step 2: Management of Associated Injuries

Crista supinatoris fractures have not been identified in isolation; address associated injuries such as radial head/neck fractures, capitellar fractures, and coronoid fractures first.

- To fix or replace the radial head, perform an arthrotomy anterior to the lateral ulnar collateral ligament through the radial collateral and annular ligaments at the level of the mid-equator of the radial head.
- Use an extended modified Kocher approach[4] to visualize and fix capitellar and coronoid fractures. Detach the extensor carpi ulnaris, extensor digitorum communis, and extensor carpi radialis brevis from the lateral epicondyle and elevate the extensor carpi radialis longus and brachioradialis off the supracondylar ridge, as needed.
- When treating coronoid fractures through the extended modified Kocher approach, we often use retrograde posterior-to-anterior screw fixation[5] or a suture lasso technique[6]. Fix capitellar fractures with posterior-to-anterior cannulated or non-cannulated screws, anterior-to-posterior variable-pitch headless screws, or threaded Kirschner wires. In the presence of posterior column comminution, we prefer using plate fixation through a column approach[7].
- Use a separate medial approach to access an anteromedial coronoid fracture if present.

Step 3: Evaluation of Elbow Stability

If elbow instability persists after the concomitant injuries have been addressed, fix the crista supinatoris.

- Although an evidence-based treatment algorithm for crista supinatoris fractures does not exist, we use persistent elbow instability following the treatment of concomitant injuries as an indication for surgical fixation.
- Following the surgical management of the associated fractures, examine elbow stability in flex-

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

ion and extension with the forearm in supination, neutral, and pronation. Use dynamic fluoroscopy to identify subtle instability when performing the stability tests.

Varus Stress Testing

- Instability is confirmed when widening of the radiocapitellar joint and lateral ulnohumeral joint space is observed under fluoroscopy while varus stress is applied to the elbow in 30° of flexion (Figs. 5-A and 5-B).
- A positive varus stress test suggests insufficiency of the lateral collateral ligament.
- Do not assess ligamentous stability with the elbow in full extension. At terminal extension, the olecranon process engages the olecranon fossa, resulting in varus/valgus stability, and the elbow can erroneously be judged to be stable.

Valgus Stress Testing

- Pseudo-valgus instability of the elbow may be observed in the presence of posterolateral rotatory instability. Valgus angulation occurs when the radial head and coronoid subluxate posteriorly and the elbow pivots around an intact medial collateral ligament.
- Fully pronate the forearm to avoid pseudo-valgus instability when performing a valgus stress test. A true-positive test indicates an injury to the medial collateral ligament.

Posterolateral Rotatory Instability Testing

- The lateral ulnar collateral ligament acts as a major constraint to posterolateral rotatory instability[8].
- Perform a posterolateral drawer test, a hypersupination test, and a gentle posterolateral pivot-shift test to determine the integrity of the lateral ulnar collateral ligament and to determine whether residual instability is present.
- A true lateral intraoperative fluoroscopic image will demonstrate posterior subluxation of the radial head and gapping of the ulnohumeral joint in the presence of posterolateral rotatory instability (Figs. 6-A and 6-B).

Step 4: Exposure of the Crista Supinatoris

Expose the fracture fragment and base of the crista supinatoris.

- The supinator, which partially originates from the crista supinatoris, overlies the insertion of the lateral ulnar collateral ligament on the crista supinatoris (Fig. 7).
- Pronate the forearm to protect the posterior interosseous nerve. Release the proximal edge of the supinator from its origin on the ulna to visualize the fractured crista supinatoris.
- Assess the size of the fracture. Take care to leave the insertion of the lateral ulnar collateral ligament intact on the fracture fragment.
- Debride the fracture fragment and fracture bed as required to remove any block to reduction.

Step 5: Reduction and Fixation of the Crista Supinatoris Fracture

Obtain an anatomic reduction and fixation of the crista supinatoris fracture to appropriately tension the lateral ulnar collateral ligament.

Screw Fixation

- Screw fixation is preferred when a sizeable fracture fragment is present (Figs. 8-A and 8-B).
- Use a sharp reduction clamp or Kirschner wires to obtain provisional fixation of the fracture fragment.
- Use 2.0 or 2.4-mm cortical lag screws for fixation.

Suture Anchor Fixation

- Suture anchor fixation is preferred when the fracture fragment is too small to allow screw fixation (Figs. 9-A and 9-B).
- Implant one or two suture anchors in the fractured surface of the crista supinatoris on the ulna.
- Use the sutures on the anchor(s) to secure the distal end of the lateral ulnar collateral ligament and the crista supinatoris to its fracture bed.
- Pass the suture through the comminuted crista supinatoris fragment and then through the distal end of the lateral ulnar collateral ligament using a locking Krackow technique.

Step 6: Reevaluation of Elbow Stability

Gently evaluate the stability of the elbow following repair of the crista supinatoris fracture.

- Repeat the posterolateral drawer, hypersupination, and posterolateral pivot-shift tests to determine if residual instability is present.
- If stability was achieved, proceed with wound closure.
- If lateral-sided elbow instability is still present, reexamine the distal repair site for integrity and anatomic location. Also examine the midsub-

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

stance and proximal origin of the lateral collateral ligament to rule out occult injury.

Step 7: Postoperative Care

Initiate rehabilitation on the basis of intraoperative stability and concomitant injuries.

- Rehabilitation is dictated by the severity of concomitant injuries and the stability of fixation. In general, early motion is advised.
- To prevent undue stress on the lateral collateral ligament at its insertion on the crista supinatoris, supination should be performed only with the elbow at ≥90° of flexion in the early postoperative period.
- If there are no contraindications to it, consider initiating heterotopic ossification prophylaxis with oral indomethacin, 25 mg three times a day, as well as a proton pump inhibitor for three weeks postoperatively.

Results

We recently conducted a retrospective review of the outcomes of twelve patients with a fracture of the crista supinatoris[2]. None of the fractures occurred in isolation. Associated injuries included a radial head fracture in ten patients, a radial neck fracture in one patient, and a capitellar fracture in another patient. Of the twelve patients, eight underwent surgical treatment (for indications other than the crista supinatoris fracture), and five of the eight had surgical fixation of the crista supinatoris fracture.

In our series, the entire crista supinatoris was fractured as a long narrow fragment of cortical bone in seven patients whereas the crista supinatoris fracture was small in five. Only one of five crista supinatoris fractures treated operatively was fixed with screws.

When posterolateral rotatory instability was present intraoperatively, the crista supinatoris fracture was the etiology and fixation restored stability to all elbows. At a mean of thirty-nine months postinjury, concentric radiographic reduction and clinical stability were seen in all patients. The mean range of flexion and extension (and standard deviation) was 136 ± 6° and 5 ± 8°, respectively. Although our study demonstrated generally good outcomes following treatment of these injuries, the results may be more dependent on the associated injuries.

What to Watch For

Indications

- Persistent elbow instability following the treatment of concomitant injuries

Contraindications

- Medical comorbidities

Pitfalls & Challenges

- Visualization of a crista supinatoris fracture with standard radiographs is challenging. Although external oblique radiographs may be helpful, CT imaging provides the best visualization of these fractures.
- The fracture fragment may be small and comminuted and therefore not amenable to screw fixation. Therefore, be prepared to use suture anchor fixation.
- There is no evidence-based treatment algorithm for crista supinatoris fractures.

Clinical Comments

- Crista supinatoris fracture is a newly reported, unique distal disruption of the lateral ulnar collateral ligament. These fractures have been identified as a cause of posterolateral rotatory instability and as such may require surgical fixation in patients with clinical instability.
- *What type of suture anchor would you recommend to fix avulsion-type crista supinatoris fractures?* In this series, both metallic rivet-type anchors and screw-in anchors were used with success. Since the anchors are inserted into the fracture bed, which consists of cancellous bone, cortical contact is not available for rivet or barbed-type suture anchors. Therefore, metallic screw-in anchors may provide superior fixation.
- *How does rehabilitation after the treatment of crista supinatoris fractures differ from that after treatment of midsubstance and proximal lateral ulnar collateral ligament injuries?* Given that bone-to-bone healing may take place when this injury pattern is addressed with screw fixation, it is possible that more aggressive rehabilitation may be initiated earlier. However, in cases with smaller fragments and comminution requiring suture anchor fixation, standard rehabilitation protocols that protect the lateral collateral ligament should be used[9,10].

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doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

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Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. In addition, one or more of the authors has a patent or patents, planned, pending, or issued, that is broadly relevant to the work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

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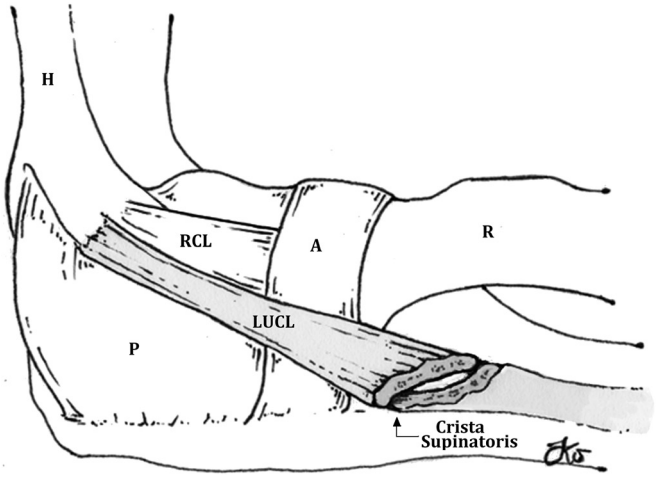


Fig. 1-A **Fig. 1-B**

Fig. 1-A Illustration depicting an osseous avulsion of the lateral ulnar collateral ligament (LUCL) at its insertion on the crista supinatoris. A = annular ligament, P = posterolateral aspect of the joint capsule, RCL = radial collateral ligament, H = distal part of the humerus, and R = radius. (Reproduced with permission of Kari Visscher, MD) **Fig. 1-B** Three-dimensional CT reconstruction of an elbow with a crista supinatoris fracture. The path of the lateral ulnar collateral ligament is highlighted in gray.

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

Fig. 2-A

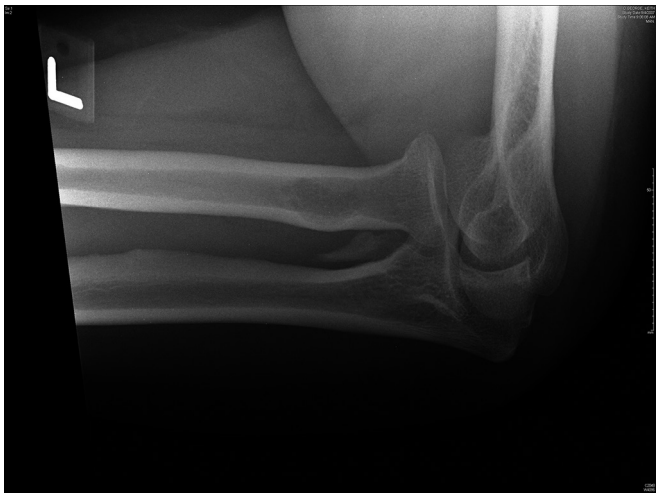
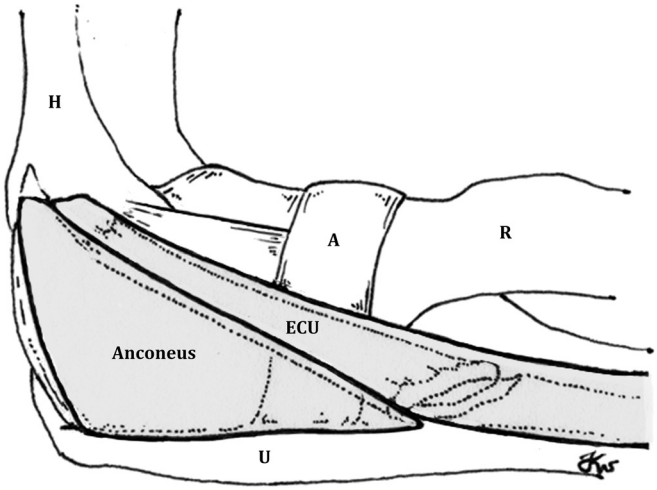


Fig. 2-B

Fig. 2-C

Figs. 2-A, 2-B, and 2-C Images demonstrating a crista supinatoris fracture and a partial articular fracture of the radial head. **Fig. 2-A** On the anteroposterior radiograph, the crista supinatoris fragment is obscured by the proximal part of the radius and is difficult to appreciate. **Fig. 2-B** The crista supinatoris fragment is clearly seen on the external oblique view. **Fig. 2-C** A three-dimensional CT reconstruction provides optimal visualization of the crista supinatoris fracture.

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4



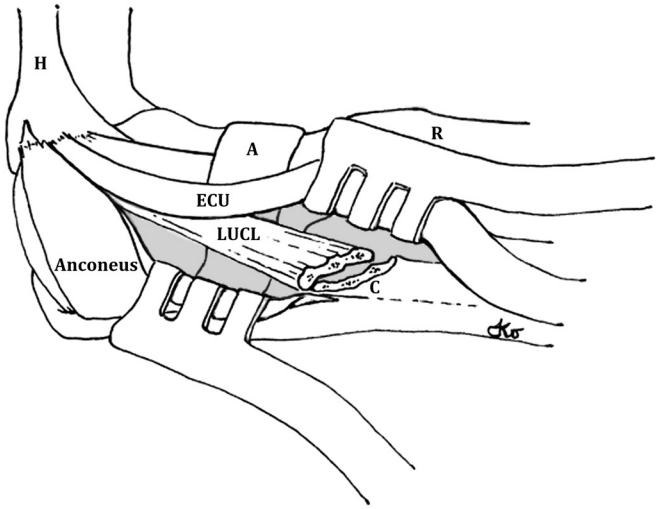


Fig. 3-A **Fig. 3-B**

Figs. 3-A and 3-B The lateral ulnar collateral ligament is located deep to the extensor carpi ulnaris (ECU) (**Fig. 3-A**) and can be approached through the Kocher interval after anterior elevation and retraction of the extensor carpi ulnaris (**Fig. 3-B**). The insertion of the lateral ulnar collateral ligament (LUCL) onto the fractured crista supinatoris (C) can be exposed by elevating the overlying proximal fibers of the supinator from their origin on the crista supinatoris. A = annular ligament, H = distal part of the humerus, R = radius, and U = ulna. (Reproduced with permission of Kari Visscher, MD.)

Fig. 4

Intraoperative image of a Monteggia-variant fracture following open reduction and internal fixation of the ulna. The white arrow points to a displaced fractured crista supinatoris fragment, as visualized through the Boyd interval. With hypersupination, the radial head (r) is posteriorly dislocated and the ulnohumeral joint (black arrow) is subluxated secondary to posterolateral rotatory instability. The radial head is congruent with the lesser sigmoid notch of the proximal radioulnar joint, but traumatic avulsion of the annular ligament from its dorsal attachment is present.

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

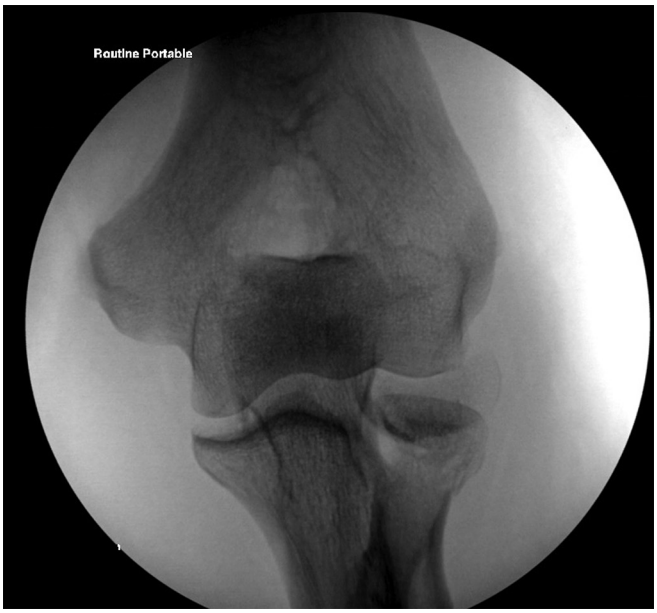


Fig. 5-A

Fig. 5-B

Figs. 5-A and 5-B Intraoperative anteroposterior fluoroscopic views of the elbow in neutral (**Fig. 5-A**) and with varus stress applied (**Fig. 5-B**). When varus stress is applied to the elbow, widening of the lateral facet of the ulnohumeral joint and widening of the radiocapitellar joint indicate an injury to the lateral collateral ligament complex, which is present in this case. A comminuted radial head fracture is also seen on the images.

Fig. 6-A

Fig. 6-B

Figs. 6-A and 6-B True lateral elbow radiographs in pronation (**Fig. 6-A**) and supination (**Fig. 6-B**). Hypersupination precipitates posterolateral rotatory instability of the elbow in the presence of an injury to the lateral ulnar collateral ligament. With hypersupination, posterior subluxation of the radial head and gapping of the ulnohumeral joint are seen radiographically (**Fig. 6-B**).

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

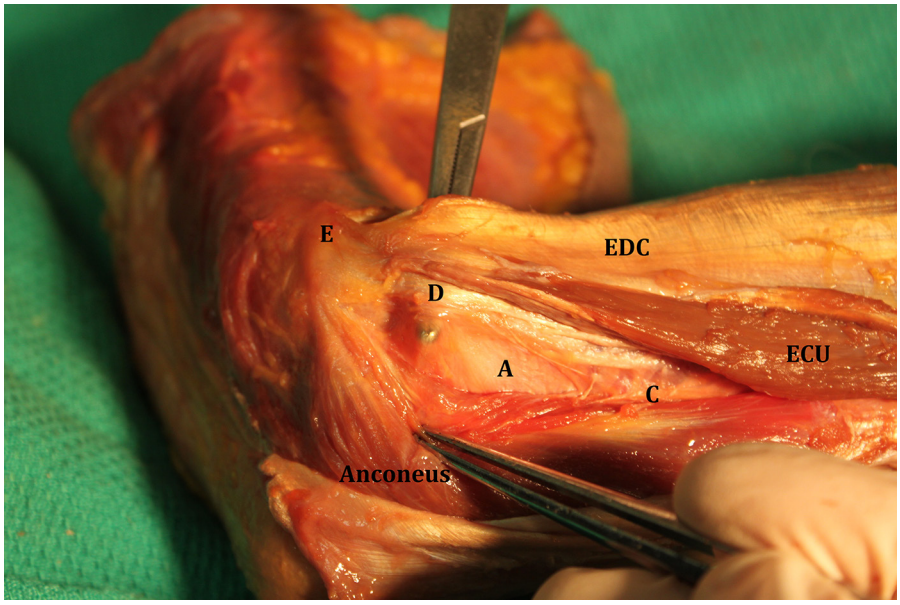


Fig. 7

Cadaveric dissection through the Kocher interval between the extensor carpi ulnaris (ECU) and anconeus. The fascia of the extensor carpi ulnaris has been excised, and its muscle belly has been mobilized anteriorly. The deep fascia (D) of the extensor carpi ulnaris is in close apposition with the lateral ulnar collateral ligament. The tip of the hemostat inserted through the Kaplan interval, between the extensor digitorum communis (EDC) and extensor carpi radialis brevis and along the radiocapitellar joint, is seen hooked around the deep fascia of the extensor carpi ulnaris and the capsular thickening representing the lateral ulnar collateral ligament. Fibers of the supinator muscle are seen overlying the distal portion of the lateral ulnar collateral ligament and its insertion on the crista supinatoris (C). These muscle fibers need to be elevated to adequately visualize a crista supinatoris fracture. A = annular ligament and E = lateral epicondyle.

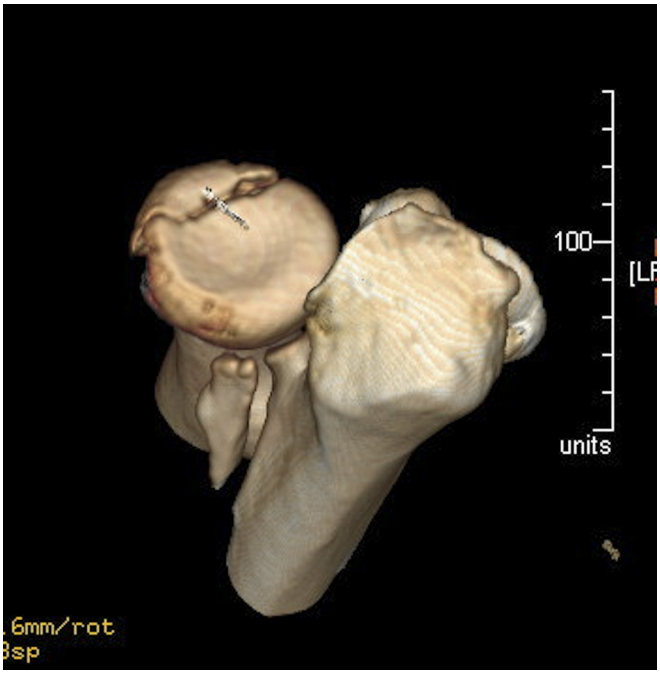


Fig. 8-A

Fig. 8-B

Fig. 8-A A displaced unstable crista supinatoris fracture and a displaced partial articular radial head fracture, both treated with open reduction and internal fixation. **Fig. 8-B** Postoperative radiograph illustrating screw fixation of the crista supinatoris fracture and radial head fracture.

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4

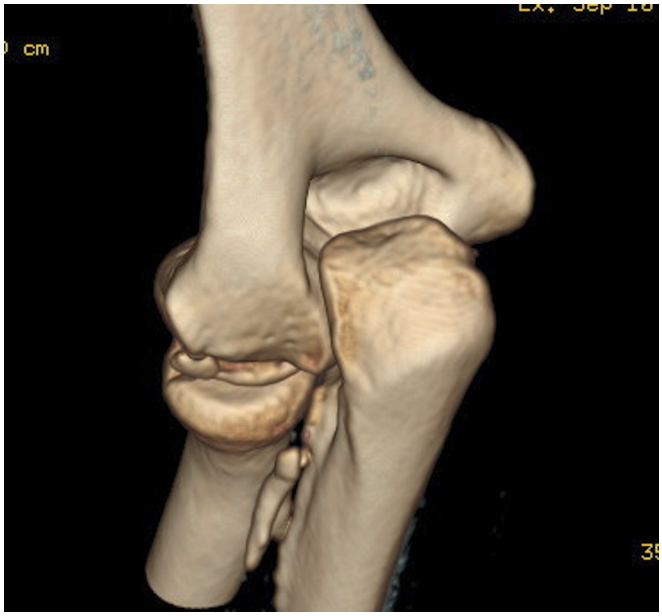


Fig. 9-A

Fig. 9-B

Figs. 9-A and 9-B A comminuted radial head fracture and an unstable displaced crista supinatoris fracture managed surgically with radial head arthroplasty and suture anchors, respectively. Transosseous sutures tied over a mini-fragment plate placed on the posterior humeral cortex were also used to repair a partially torn common extensor origin.

doi:10.2106/JBJS.ST.M.00076 2015, 5(1):e4