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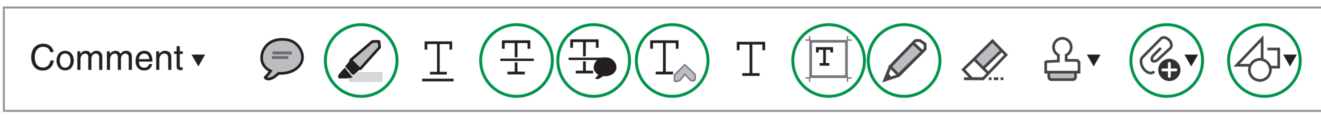

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E CASE REPORT

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Arthroscopically-assisted fixation of anteromedial coronoid facet fracture and lateral ulnar collateral ligament repair for acute posteromedial rotatory fracture dislocation of the elbow

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Abstract

If left untreated, varus posteromedial rotatory injuries of the elbow result in poor functional outcomes. Surgical treatment allows restoration of elbow kinematics, minimizing the chances of chronic varus instability and early onset osteoarthritis. However, large exposures are associated with extensive soft tissue stripping, a high risk of infection, nerve injury, poor visualization of the articular surface and longer recovery. Consequently, there has been renewed interest in the use of elbow arthroscopy to circumvent these problems. Arthroscopic treatment offers the potential advantage of a swift recovery, with instant rehabilitation, less stiffness and swelling than might be expected after open repair. We present the first combined arthroscopic-assisted anteromedial facet coronoid fracture fixation and lateral ulna collateral ligament repair in a varus posteromedial rotatory injury of the elbow.

Keywords

anteromedial facet coronoid fracture, arthroscopy, elbow, lateral ligament complex, posteromedial rotatory injury

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Introduction

Varus posteromedial rotatory instability (VPRI) of the elbow occurs when an individual falls on to a pronated outstretched arm. As the body rotates around the planted arm, an axial load and varus force is transmitted to the elbow resulting in avulsion of the lateral ulna collateral ligament (LUCL) from its humeral attachment. The ensuing posteromedial subluxation of the elbow allows the trochlea to impact the coronoid transmitting a shear force which results in a vertical or oblique fracture of the anteromedial coronoid facet (AMCF). As the force proceeds unchecked, the posterior band of the medial collateral ligament may also be damaged.[1]

Without an intact LUCL and AMFC, any varus stress will cause point loading on the medial aspect of ulnohumeral articulation, resulting in early osteoarthritis.[2,3] Application of the coronoid fracture classification by Regan and Morrey[4] may result in the relative under-treatment of these injuries. O'Driscoll et al.[5] have therefore classified coronoid fractures type 1-tip, type 2-AMFC and type 3-basal, then further subclassified AMFC fractures into rim, rim & tip, rim & sublime tubercle ± tip subtypes to guide treatment (Fig. 1).[5] Biomechanical data suggest that reattachment of the LUCL back to the humeral origin alone is sufficient to restore elbow stability if accompanied by a rim subtype AMFC fracture.[6] However, when

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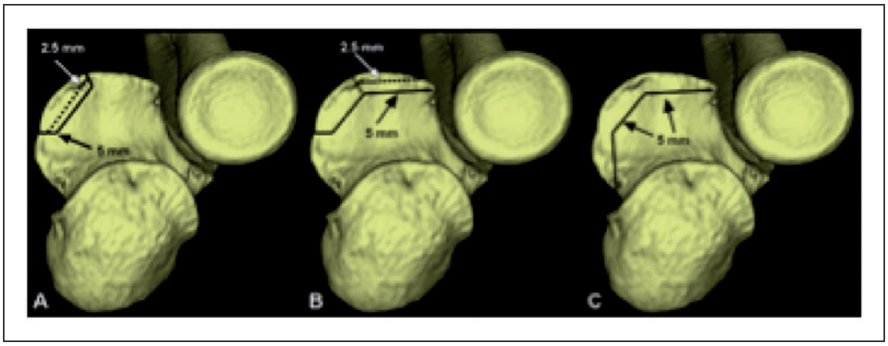

Figure 1. O'Driscoll type 2 anteromedial coronoid fracture classification. (A) Rim subtype. (B) Rim & tip subtype. (C) Rim & sublime tubercle ± tip. Reproduced from O'Driscoll et al.[5]

Figure 2. Lateral radiograph demonstrating a coronoid fracture.

Figure 3. Anteroposterior radiograph demonstrating a small bony avulsion of the lateral ligament complex from its humeral origin, as well as a slight opening of the radial side of the joint in keeping with this injury pattern.

accompanied by a larger AMFC fracture, the bony component needs to be addressed in addition to the LUCL.[6] This necessitates large exposures to the medial and lateral aspects of the elbow, which are associated with extensive soft tissue stripping, infection, nerve injury, poor visualization of the articular surface and longer recovery.[7]

We report the first arthroscopic-assisted AMFC fracture fixation and LUCL repair in a patient with VPRI.

Case Report

A 47-year-old right-hand dominant lady injured her left elbow when tobogganing. She had been thrown into the air and landed on a backward outstretched hand. She heard a 'crack' on impact and recalled immediate pain and diffuse swelling. Radiographs taken in the emergency department did not show an obvious dislocation of the elbow and so she was treated in a broad arm sling. She was seen in the fracture clinic of the senior author (AW) 9 days later, complaining of central elbow pain. On examination, she had anteromedial elbow bruising, tenderness over the coronoid, tenderness over the lateral epicondyle and apprehension on varus stress testing. Review of the index radiographs showed a small, displaced coronoid fracture, slight asymmetry of the ulnohumeral articulation and a small sliver of bone adjacent to the lateral epicondyle suggestive of a lateral ulna collateral ligament avulsion (Figs 2 and 3). A computed tomography (CT) scan confirmed an

Figure 4. Three-dimensional computed tomography reconstruction demonstrating a fracture of the anteromedial facet of the coronoid.

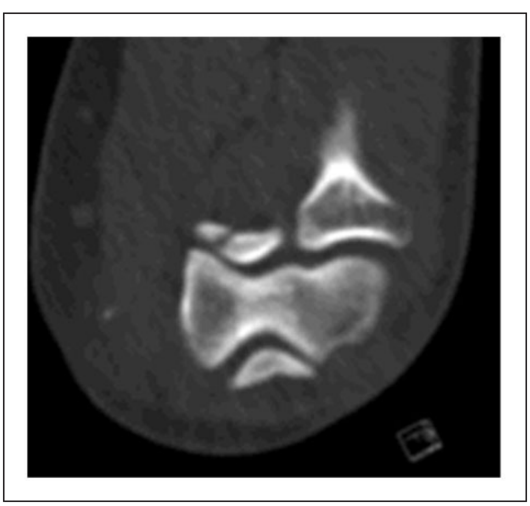

Figure 5. Coronal view of the elbow demonstrating a fracture of the anteromedial facet of the coronoid and a degree of gapping on the lateral side of the joint.

O'Driscoll rim subtype type AMFC fracture possibly extending into the tip (Figs 4 and 5). Given her relatively young age and high functional demand, it was elected to treat her surgically.

Figure 6. Arthroscopic view of coronoid fracture.

Operative technique

Under a general anaesthetic and supraclavicular block, the patient was placed in the lateral decubitus position with the arm held in a Trimano positioner (Arthrex, Naples, FL, USA). An examination under anaesthesia demonstrated radiocapitellar and lateral ulnohumeral gapping with varus stress testing. Next, 20 mL of 7.5 mg/mL ropivacaine was injected into the posterior compartment of the elbow to facilitate arthroscopy and provide intra-articular anaesthesia. The arm was exsanguinated and the high-arm tourniquet inflated to 250 mmHg. Standard anteromedial and anterolateral arthroscopic viewing portals were created and a diagnostic arthroscopy was performed with a 70° 4-mm arthroscope. This confirmed the coronoid fracture and a humeral avulsion of the lateral ligament complex (Figs 6 and 7).

Arthroscopic fixation of the coronoid fracture

A tip-aiming ACL guide was passed into the joint and used to facilitate fracture reduction. A threaded 1.2-mm K-wire was then passed through the dorsal surface of the ulna into the coronoid. This achieved rotational stability of the fracture such that no further hardware was deemed necessary. The wire was cut slightly proud of the dorsal cortex of the ulna.

Arthroscopic-assisted lateral ulnar collateral ligament repair

The torn edge of the avulsed lateral ligament was defined and gently debrided with an arthroscopic soft-tissue shaver. Two number 2 Orthocord (Depuy Synthes, Raynham, MA, USA) sutures were then

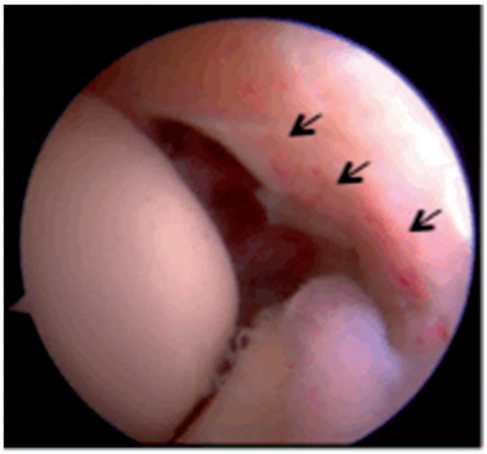

Figure 7. Arthroscopic view of radiocapitellar articulation showing loss of congruity secondary to lateral ligament sleave avulsion (arrows).

passed arthroscopically from proximal to distal and then proximal again to form a mattress suture in the capsular ligament tissue. A 2-cm incision was then made directly over the lateral epicondyle and the footprint of the lateral ligament was identified. A 2-mm bone socket was drilled under direct vision, with additional image intensifier control. The Orthocord suture was loaded onto a 2.9-mm PEEK Pushlock anchor (Arthrex), the sutures were tensioned and the anchor was inserted as the arm was held pronated and with valgus force applied. The elbow was then dynamically screened and was shown to be stable.

The wounds were closed with absorbable subcuticular sutures, a soft dressing was applied and the elbow was placed in a sling. Postoperatively, the patient was instructed to commence gravity-assisted flexion in the supine position with the forearm pronated and without abducting the shoulder for the first 4 weeks, with gradual return to normal motion thereafter.

At 12 months follow-up, the patient was pain free, had a full unrestricted range of movement and had no symptoms of elbow instability. She had returned to work and had a mean functional elbow assessment score of 0. Postoperative radiographs did not show any degenerative changes or subluxation (Fig. 8). Postoperative CT evaluation was therefore not undertaken.

Discussion

VPRI involves injury to both varus restraints of the elbow, namely the LUCL and the AMFC. The latter is particularly prone to injury because 60% of it is unsupported by the ulna metaphysis. Left untreated, the application of varus stress may allow the lateral ulnohumeral joint to gap open, resulting in point loading of the medial ulnohumeral joint. This ensuing increase in contact forces may culminate in early osteoarthritis.[3]

Figure 8. Postoperative anteroposterior radiograph showing restoration of joint line congruency.

The clinical presentation is often subtle, with the majority of patients not reporting a frank dislocation. Bringing the arm from flexion to extension will reproduce the varus posteromedial load, resulting in pain. Anteroposterior radiographs may show a narrowed or incongruent medial ulnohumeral joint space, coupled with gapping of the lateral ulnohumeral and radiocapitellar joint spaces, along with bony fragmentation adjacent to the lateral epicondyle from LUCL avulsion. Lateral radiographs may show loss of parallelism between the trochlea and the coronoid and possibly a double crescent sign indicating a depressed AMCF fracture. Computed tomography scans confirm the depressed anteromedial coronoid fragment and three-dimensional reconstructions may reveal the rotatory subluxation.

Surgical treatment usually involves a posterior skin incision with medial and lateral full-thickness fasciocutaneous flaps to access both sides of the elbow or two separate skin incisions. Although the AMCF fracture can be exposed through any of the medial approaches, the flexor carpi ulnaris splitting approach provides the widest exposure of the coronoid, proximal ulna and the medial collateral ligament (MCL). The distal attachment of the MCL to the sublime tubercle is usually intact because AMCF fractures do not normally propagate beyond this. Fracture fixation can be achieved using threaded K-wires, screws or buttress plates, depending upon fracture size and configuration. The LUCL is exposed through the Kocher's interval and re-attached to its humeral insertion through bone tunnels or with suture anchors.

Doornberg and Ring[2] reported the outcomes of 18 patients with VPRI (11 treated surgically and seven treated non-operatively) with a mean follow-up of 26 months. Nine of 18 were considered to have insufficient AMCF fixation (including all seven non-operatively treated patients) had a mean flexion arc of 99°, a mean Broberg–Morrey rating of 83, radiographic evidence of osteoarthritis, on-going elbow instability and a fair–poor functional result. The remaining nine patients were considered to have secure AMFC fixation had a mean flexion arc of 131° and a mean Broberg–Morrey rating of 97. These findings support the notion that functional outcomes are better with surgical treatment. Pollock et al.[6] loaded 10 cadaveric elbows using a motion simulator in the presence of AMFC fractures of varying size with concurrent LUCL insufficiency before and after repair. They found that the size of the AMCF fracture had a significant impact on elbow kinematics. In rim subtype AMFC fractures, isolated repair of the LUCL was sufficient to restore elbow stability, whereas in rim & tip and rim & sublime tubercle subtypes, elbow stability could only be restored with fracture stabilization and LUCL repair. Park et al.[3] reported favourable outcomes in 11 patients who were treated based on this algorithm.

Conventional open approaches require extensive detachment of the anterior capsule from the proximal ulna to facilitate exposure of the fracture. This may jeopardize the vascularity of the fracture fragments, which, when combined with small fracture fragments and comminution, may result in marginal fixation and residual instability. Furthermore, compromising the structural integrity of the anterior capsule may result in loss of its function as a stabilizing structure.[8] Several studies have turned to arthroscopy to circumvent some of these issues.[3,8,9] Kim et al.[12] [AQ4] reported the results of arthroscopic LUCL repair in 13 patients with a mean age of 25 years, all of whom had posterolateral rotatory instability after simple elbow dislocation. At the time of final follow-up, at a minimum of 18 months, all 13 patients reported complete resolution of the instability and mean (SD) extension of 3° (1°), flexion of 138° (6°), supination of 88° (5°) and pronation of 87° (6°). The mean motor evoked potential was 92 and, according to this validated outcome score, the results were rated as excellent in 12 patients and good in one patient. Complete healing was seen on the 3-month follow-up magnetic resonance image in 12 patients; however, one patient had mild widening of the radiocapitellar joint space with incomplete healing but no instability symptoms. All patients demonstrated normal strength on elbow flexion, extension, pronation and supination at the final follow-up visit.[12] Hausman et al.[8] described arthroscopic-assisted reduction and internal fixation in four consecutive patients with type I and II-AMFC fractures with the addition of open LUCL repair as required. At a minimum follow-up of 1 year (mean, 76 weeks; range 58 weeks to 92 weeks), all patients achieved a functional range of motion with an average flexion/extension arc of 2.5° to 140° and full pronation and supination. No patient had recurrent elbow instability. One patient had removal of a prominent suture over the subcutaneous border of the ulna.

Despite the technical demands of elbow arthroscopy, the benefits of less postsurgical pain, reduced arthrofibrosis, minimal infection risk and easier postoperative rehabilitation make it an attractive proposition. Recently, indications have expanded to include synovectomy, radial head excision, osteocapsular arthroplasty and extensor carpi radialis brevis release. Although neurological complications have been reported, numerous outcome studies have established that it is generally a safe procedure when appropriate precautions are taken. The risk of major and minor complications is approximately 4.8% (most commonly deep infection requiring washout) and 8.9% (most commonly superficial wound infection requiring antibiosis), respectively.[11] Other minor complications include portal site ganglion, heterotopic ossification and ossification in the triceps. Despite worries about neurological complications, these complications are in fact quite rare, with the incidence of transient neurological problems being reported at 1.7% (most often the radial nerve). Although the risk of nerve injury is higher than in the shoulder and the knee, most are transient with good chance of full resolution (1.7% to 2.5%). There is certainly no association between the complexity of the procedure or patient comorbidity and the risk of complications.

The majority of patients do not recall an obvious dislocation and the radiographic appearance is usually innocuous. Consequently, the majority of injuries are not recognized and therefore are treated non-operatively. The literature suggests that, if the AMFC and LUCL fail to heal in satisfactory manner, the net effect is point loading of the medial aspect of the ulnohumeral joint under varus stress, culminating in osteoarthritis. Many surgeons therefore will treat even undisplaced fractures operatively to avoid the post-traumatic sequelae. The radiological configuration influences the surgical approach one chooses. Because the coronoid fracture in our case was minimally displaced and the trochlea not subluxed, we chose to proceed arthroscopically. Had this not been the case, we would have chosen to proceed to an open approach. This reflects that the surgeon should keep all their options open and not adopt a 'one size fits all' approach to such injuries.

Conclusions

Arthroscopically-assisted management of coronoid fractures can provide excellent observation, enabling anatomic repair without extensive soft tissue dissection. Preservation of the soft tissue attachments of small coronoid fragments and repair of the capsule are possible with this technique. Furthermore, compared to open surgery, there is less scarring, a reduced risk of infection, less postoperative pain and thorough visualization of the joint. Our case supports the use of arthroscopy in the acute setting in apparently complex elbow injuries.

Declaration of conflicting interests

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Ethical review and patient consent

The patient has given their consent for the use of the images.

References

1. Sanchez-Sotelo J, O'Driscoll SW and Morrey BF. Anteromedial fracture of the coronoid process of the ulna. *J Shoulder Elbow Surg* 2006; 15: e5–e8.
2. Doornberg JN and Ring D. Coronoid fracture patterns. *J Hand Surg Am* 2006; 31: 45–52.
3. Park SM, Lee JS, Jung JY, Kim JY and Song KS. How should anteromedial coronoid facet fracture be managed? A surgical strategy based on O'Driscoll classification and ligament injury. *J Shoulder Elbow Surg* 2015; 24: 74–82.
4. Regan W and Morrey B. Fractures of the coronoid process of the ulna. *J Bone Joint Surg Am* 1989; 71A: 1348–1354.
5. O'Driscoll SW, Jupiter JB, Cohen MS, Ring D and McKee MD. Difficult elbow fractures: pearls and pitfalls. *Instr Course Lect* 2003; 52: 113–134.
6. Pollock JW, Brownhill J, Ferreira L, McDonald CP, Johnson J and King G. The effect of anteromedial facet fractures of the coronoid and lateral collateral ligament injury on elbow stability and kinematics. *J Bone Joint Surg Am* 2009; 91: 1448–1458.
7. Pugh DM, Wild LM, Schemitsch EH, King GJ and McKee MD. Standard surgical protocol to treat elbow dislocations with radial head and coronoid fractures. *J Bone Joint Surg Am* 2004; 86: 1122–1130.
8. Hausman MR, Klug RA, Qureshi S, Goldstein R and Parsons BO. Arthroscopically assisted coronoid fracture fixation: a preliminary report. *Clin Orthop Relat Res* 2008; 466: 3147–3152.
9. Savoie FH III, Field LD and Gurley DJ. Arthroscopic and open radial ulnohumeral ligament reconstruction for posterolateral rotatory instability of the elbow. *Hand Clin* 2009; 25: 323–329.
10. Kelly EW, Morrey BF and O'Driscoll SW. Complications of elbow arthroscopy. *J Bone Joint Surg Am* 2001; 83: 25–34 [AQ5].
11. Nelson GN, Wu T, Galatz LM, Yamaguchi K and Keener JD. Elbow arthroscopy: early complications and associated risk factors. *J Shoulder Elbow Surg* 2014; 23: 273–278.
12. Kim JW, Yi Y, Kim TK, et al. Arthroscopic lateral collateral ligament repair. *J Bone Joint Surg Am* 2016; 98: 1268–1276.