Elbow Fracture-Dislocations
The Role of Hinged External Fixation

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Abstract
Fracture-dislocations of the elbow remain a complex problem in orthopaedics. The myriad of treatment protocols and methodologies focuses on precise articular alignment and restoration of the skeletal architecture. The goal is to re-establish function as quickly as possible so as to allow rehabilitation involving the full range of motion. Surgical management, primarily reconstruction of the secondary stabilizers of the elbow joint as well as preserving soft tissue structures, subsequently provides the possibility of a speedier recovery. If proper skeletal alignment does not confer enough stability, hinged external fixation becomes an integral part of the treatment strategy for the reconstructive and trauma surgeon.

Elbow dislocations represent 10% to 25% of all injuries to the elbow, in patients with a mean age of 30.1 The incidence is 6 per 100,000.2 The elbow joint is among the most commonly dislocated major joint, second only to the shoulder. The usual mechanism is sports related: from a fall on an outstretched hand. The nature of the bony anatomy of the elbow, in particular, the subcutaneous position of the olecranon, predisposes this region to frequent dislocations.3 Elbow dislocations are classified as simple dislocations if they are not associated with concomitant periarticular fractures. Those dislocations associated with periarticular fractures are classified as complex. One study has shown that 100% of elbow dislocations are associated with unrecognised osteochondral fractures, however, only those readily radiographically identifiable fractures are termed “complex.” Elbow dislocations can be associated with radial head fractures, coronoid fractures, capitellar or trochlear fractures, olecranon fractures, or any combination of these (Fig. 1).3,4 Elbow dislocations are named for the direction of the displacement of the distal fragment. The posterior dislocation is by far the most common. The anterior dislocation and divergent dislocation (the humerus goes in between the radius and ulna) are rare and associated with higher energy trauma.5 The elbow joint can also dislocate through a widely displaced distal olecranon fracture, referred to as a trans-olecranon dislocation.5

Pathomechanics
Elbow injuries represent a spectrum of instability that starts as posterolateral instability, progresses to a perched dislocation, and then proceeds to a complete dislocation. During an elbow dislocation all supporting ligaments of the elbow (including the medial collateral ligament, lateral ulnar collateral ligament, and the anterior and posterior capsule) are disrupted. In most cases the muscular origins at the epicondyles are also disrupted.5,6

After closed reduction of a simple elbow dislocation the majority of cases demonstrate immediate stability in the flexion-extension arc. This stability is derived from the skeletal architecture. The ulno-humeral joint is extremely congruent and imparts a great deal of stability throughout the arc of motion. In full extension the olecranon process locks into the olecranon fossa and in full flexion the coronoid process locks into its fossa. Valgus stability is provided by the radiocapitellar articulation, as the radial head acts as a secondary stabilizer to resist valgus stress.7-10

The ulnar collateral, or medial collateral ligament, is the main stabilizer against valgus loads.7,8,9 The ligament originates from the medial epicondyle and inserts onto the
sublime tubercle of the proximal ulna. The ligament has been found to consist of three distinct bands. The posterior bundle is confluent with the posterior capsule of the elbow joint. The transverse bundle contributes little to the stability of the elbow as both its origination and insertion are on the ulna. The anterior bundle is the most important part of the ligament. It is a fan-shaped structure that become taut in extension, juxtaposed by the posterior fibers, which are taut in flexion. Its origin is just posterior to the axis of flexion and extension of the ulno-humeral joint.6,9,10

The radial collateral ligament, or lateral collateral ligament, has its origination at the lateral humerus at the midpoint of the trochlea and capitellum on the axis of rotation of the elbow. It then courses distally in a fan-like pattern before merging with the annular ligament and inserting via conjoined fibers onto the proximal ulna. These two form the lateral ligamentous complex which maintains the ulno-humeral and radio-capitellum articulations.

Injury to the lateral ligamentous structures results in a posterolateral rotatory instability of the elbow.7,9-11

The Stable Elbow

After reduction of the standard posterior elbow dislocation (Fig 1B), the elbow can be put through a careful active range of motion under the direct supervision of the surgeon. This can give invaluable information about the post-reduction stability. The elbow becomes more stable with increasing flexion and pronation. The number of degrees of extension at which the elbow starts to feel unstable or starts to subluxate or dislocate should be noted. An elbow is considered stable if it remains reduced through a range of motion of 40° of extension lag to full flexion, with the forearm in neutral rotation. By convention this is referred to as a range of motion of 40° to 135°. If the elbow has to be flexed to more

Figure 1 A, A 43-year-old male with unstable fracture dislocation of the elbow. B, Lateral film showing concentric reduction, a fractured radial head, and a coronoid MCL avulsion.

Figure 2 Intra-operative examination: unstable to valgus stress, even after radial head replacement, dislocatable posterolaterally with flexion of less than 60°.
than $60^\circ$ in order for it to remain reduced, it is considered unstable and a candidate for surgical intervention. There is also almost universal agreement that an elbow that remains stable at $40^\circ$ or less of extension is really stable and can be successfully treated without surgery.\textsuperscript{12} The zone between $40^\circ$ and $60^\circ$ is a gray zone of instability.

Assuming that the elbow is stable through a range of $40^\circ$ to $135^\circ$, the patient is immobilized with a posteriorly applied long arm splint that starts high up on the humerus and extends to just proximal to the middle palmar crease. Elevation and digital range of motion are encouraged. The patient should then be evaluated between 3 to 7 days after splinting and the plaster slab removed. The elbow can be placed through an active assisted range of motion and stability again verified. Anteroposterior and lateral radiographs should be obtained to ensure a concentric reduction of the ulno-humeral joint. Careful attention to a true lateral radiograph is important to avoid missing an incongruent reduction, or an incarcerated osteochondral fragment in the joint. Immobilization beyond two to three weeks can lead to excessive scarring and loss of motion.\textsuperscript{13} There is an average loss of $10^\circ$ of terminal extension associated with elbow dislocations. The degree and incidence of secondary elbow stiffness rises with increased immobilization and the presence of associated injuries and re-manipulation of the elbow.\textsuperscript{13}

**Radial Head Fractures**

Radial head fractures are relatively common and seen in up to 20\% of all trauma to the elbow.\textsuperscript{3} The radial head fractures are caused by a valgus force on the elbow as the head is driven into the capitellum. Radial head fractures have been classified into four types according to Mason.\textsuperscript{14} Type one fractures are nondisplaced fractures that are typically treated nonoperatively. Type two fractures are displaced fractures involving 30\% of the articular surface. The management of these is controversial with some surgeons using a significant block to motion as the determining factor between ORIF and nonoperative treatment. Type three fractures are comminuted and require excision or implant arthroplasty in the setting of elbow or forearm instability. Type four radial head fractures are those associated with elbow dislocation; these are usually displaced fractures and often comminuted.\textsuperscript{3,13}

Isolated radial head fractures will not make the elbow unstable. However, when seen in the setting of elbow dislocations the radial head becomes important. The radial head functions as a secondary stabilizer against valgus force when the medial collateral ligament is incompetent.\textsuperscript{15}

Restoring the skeletal architecture by means of open reduction and internal fixation (ORIF) or arthroplasty of the radial head serves to stabilize the elbow in this setting. Examination of the wrist joint is also important when radial head fractures are noted since concomitant wrist pain can indicate a disruption of the interosseous membrane and sprain of the distal radio-ulnar joint (The Essex-Lopresti lesion). The presence of a medial hematoma, usually indicating a tear of the MCL in association with the radial head fracture, helps the examiner to understand that the injury is not isolated to the radial head.

If the Essex-Lopresti lesion is suspected it is important to perform an ORIF or arthroplasty rather than to excise the radial head.\textsuperscript{16} Excision of the radial head can lead to proximal migration of the radius. When performing a radial head arthroplasty to restore stability to the elbow or in the case of the Essex-Lopresti lesion, it is important to use a radial head of sufficient size to prevent migration and optimize radio-capitellar contact. The radiocapitellar articulation is difficult to reproduce with the current available implants, thus...

**Figure 3** Placement of hinged external fixator showing correct centering on humero-ulnar axis of rotation.

**Figure 4** Placement of hinged external fixator showing correct centering on humero-ulnar axis of rotation.
a significant portion of radial head implants have to be revised due to persistent pain. Recent developments, such as a bipolar prosthesis hold promise in improving articulation.\textsuperscript{17,18}

**Capitellum Fractures**

Fractures of the capitellum are generally classified into two types: smaller, shear fractures (Kocher-Lorenz); and larger, body fractures (Hahn-Steinthal).\textsuperscript{19} Although small shear fragments can effectively be excised, larger fragments, especially those that extend medially into the trochlea, can destabilize the elbow and should be fixed. Osteochondral damage to the articular surface of the capitellum is often noted in elbow fracture dislocations.

**Coronoid Fractures**

The coronoid serves as an important stabilizer of the elbow. The coronoid sits anterior to the humerus and prevents anterior slide of the humerus on the ulna. Regan and Morrey\textsuperscript{20} have classified the coronoid fractures into three types. Type one fractures involve the tip of the coronoid and represent an indicator of an elbow dislocation and ligament avulsion. Type two fractures involve 50\% of the coronoid. Type three fractures involve a fracture through the base of the coronoid. Type two and three fractures render the elbow unstable. It has been shown that at least 50\% of the coronoid must be present in order for it to effectively function as an anterior door stop to humeral translation. A more recently recognized fracture pattern – the type four fracture – involves a sagittal fracture of the body of the coronoid that involves the MCL attachment to the sublime tubercle. This fracture pattern is caused by a varus moment applied to the elbow in an extended position.

Open reduction and internal fixation of a coronoid fracture is an important step in restoring elbow stability. The large fracture fragments can be fixed directly or indirectly with placement of a screw or specially designed buttress plates.\textsuperscript{13,21} The more challenging, and unfortunately more common scenario, is when there is comminution of the fragment and ORIF is not possible. In this circumstance reattachment of the anterior soft tissues and ligaments through the use of suture anchors or drill holes serves as a salvage procedure.\textsuperscript{13,21}

**Current Approach to the Complex Elbow Fracture Dislocation**

There are several ways to approach the elbow surgically.\textsuperscript{22,23} The posterior approach is an extensile approach that allows the posterior, lateral, and medial sides of the elbow to be
exposed through one incision. Other surgeons have described a separate medial and lateral incision. This also allows access to medial and lateral aspects of the joint with possibly better access to the anterior structures. The medial approach to the elbow, however, is associated with higher morbidity and surgical time as the medial cutaneous nerves have to be dissected and protected. Injury to these structures can result in a painful scar.22,23

The posterior approach involves an incision down to the deep fascia and full thickness flaps are elevated anteriorly and laterally. The deep portion of the Kocher interval can be developed for access to the radio-capitellar joint. Minimally comminuted radial head fractures can be fixed with ORIF. Severely comminuted fractures are treated with radial head arthroplasty. It is advantageous to fix a coronoid fracture prior to replacing the radial head. When the comminuted radial head has been excised, the coronoid can be visualized through the defect. To get better visualization of the anterior structures, the lateral capsule attachment and the remaining muscular attachments to the supracondylar ridge can be elevated. This allows the elbow to be subluxated out and the coronoid can sometimes be fixed by this approach.22

After stabilization of the radial head, either via ORIF or implant arthroplasty, the elbow is reduced and stability is assessed both radiographically and clinically. Intraoperatively the elbow is considered stable if it does not re-dislocate or subluxate at 40° of extension.24 Alternatively, if the elbow has to be excessively flexed and pronated then it is considered unstable.24 As discussed above, different authors may differ on the degree of instability that is excessive; however, almost all are within the range of 40° to 60° (Fig. 2). The range of motion just described is measured with the forearm in neutral rotation. If the forearm has to be kept in pronation to keep the elbow from subluxating intraoperatively, then it is probably too unstable.

If after fixation of the radial head and coronoid the elbow is still unstable, the surgeon must decide whether to dissect medially to repair the MCL or proceed directly to external fixation. While each of these approaches has merits in certain cases, it is this author’s preference to stabilize the elbow with a hinged dynamic fixator at this point. By stabilizing the elbow one can decrease both the morbidity and extensive dissection that accompany the medial approach to the elbow.25

If the coronoid and radial head have been addressed and stabilized, the fixator can reliably impart enough stability to the elbow so that the medial collateral ligament does not have to be directly sutured.25-27 The medial collateral
ligament is torn 100% of the time in a simple dislocation, and late instability from the ligament not healing, even when treated by closed means, is exceedingly rare. Once the elbow has been stabilized by external fixation, immediate range of motion can be started, allowing the MCL to heal and remodel while protecting the ligament against valgus stress. This concept is similar to that of treating the medial collateral ligament (MCL) sprain in the knee and has a good track record in that regard.

The technique of external hinged fixator application has been well described previously and the authors refer the reader to the descriptions by Jupiter and Ring, as well as McKee and colleagues. Refer to Figures 3, 4 and 5 for examples of correct placement of a hinged external fixator.

On the other hand, advocates of direct MCL repair believe that by suturing the MCL the elbow may be rendered stable enough so that the use of the hinge can be avoided. The hinged fixator does present some morbidity to the patient and requires spending more time in the operating room. The procedure is technically demanding and the learning curve not very forgiving. The possibility is quite real, however, that after repairing the MCL the elbow will still be unstable. In that situation one has the option of putting the hinge on or immobilizing the elbow postoperatively. The latter choice would be associated with increased elbow stiffness and should be avoided if the clinical conditions allow.

When the elbow is immobilized postoperatively with splints and casts, it is usually necessary to place the elbow in some degree of pronation and flexion, preferably in a hinged brace, to start some motion as soon as soft tissues allow. Careful follow up is then needed to gradually allow progressively more extension and supination. The danger exists that the elbow could re-dislocate, especially in the first few weeks. Thus during the course of the first three weeks some surgeons will follow these patients weekly with radiographic as well as clinical examinations. Refer to Figures 6 and 7 as examples of postoperative follow-up radiological and physical examinations. If the elbow should re-dislocate, even if caught in a timely basis, the patient will have to return to the operating room. There is a much higher rate of heterotopic ossification and stiffness associated with elbows that have repeat procedures within the first few weeks of the index procedure.

Other alternatives to hinged fixation for stabilizing the ulno-humeral joint, such as trans-capitellar or trans-olecranon Steinman pins, should be avoided as they cause additional articular damage and elbow stiffness.

**Conclusion**

Elbow fracture-dislocations are among the most challenging problems facing orthopaedic surgeons. These complex injuries can be effectively treated through a stepwise and logical approach. The goal is to restore enough stability to the elbow so that a functional range of motion can be started.
and maintained. By reconstructing the bony anatomy most elbows can be rendered stable. This is accomplished by addressing the anterior deficit with fixation or bone grafting the coronoid and by restoring the secondary stabilizer to valgus stress by fixation or arthroplasty of the radial head. If restoring the skeletal anatomy does not impart enough stability, then hinged external fixation is an invaluable asset in the armamentarium of the trauma and reconstructive surgeon.

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References