The case:

Enhance your diagnostic skills with this “test yourself” monthly column, which features a radiograph and challenges you to make a diagnosis.

Figure: A 34-year-old man presented with severe elbow pain after a fall. Magnetic resonance imaging was obtained after radiographs (not shown). Coronal fast spin-echo (FSE), proton density (PD), fat-saturated (FS) magnetic resonance image of the left elbow showing a rupture of the anterior band of the medial collateral ligament, a high grade tear of the radial collateral ligament proper, and small contusions of the radial head and capitellum (A). Sagittal FSE PD FS magnetic resonance image through the ulnohumeral joint showing a rupture of the anterior and posterior joint capsule with an extravasation of fluid into the adjacent soft tissues and a high-grade rupture of the distal brachialis muscle (B). Axial FSE PD FS magnetic resonance image showing the posterior capitellar contusion and hemorrhage throughout the elbow soft tissues (C).

Your diagnosis?

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Diagnosis:

Elbow Dislocation

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Answer to Radiologic Case Study
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Acute elbow dislocation is the second most common joint dislocation in the adult population and the most common joint dislocation in the pediatric age group. The annual incidence rate of simple and complex elbow dislocations in children and adults is approximately 5 per 100,000 people annually, and adolescent boys are at the highest risk for elbow dislocation.1 Elbow dislocations can either be simple or complex; simple dislocations involve injury to the ligaments without any fractures, whereas complex dislocations are accompanied by ligamentous injury and fracture.

Etiology

More than half of acute elbow dislocations occur during sports activities or are secondary to falls and commonly involve the nondominant elbow.1,2 The mechanism of posterior elbow dislocations usually involves external rotation of the forearm with a valgus force and compressive load while falling onto an outstretched arm.3 Most elbow dislocations are simple and are frequently posterior, whereas anterior, medial, lateral, and divergent dislocations are rare. When complex dislocations occur, the majority of patients present with either a coronoid process or a radial head fracture. Elbow dislocation with fractures of both the coronoid process and radial head is termed the terrible triad and occurs in approximately half of complex dislocations.4 Olecranon, capitellar, and trochlear fractures occur infrequently.

Acute anterior dislocations are rare and are more commonly seen in young patients. The mechanism for anterior dislocations is similar to that of posterior dislocations but occurs with the elbow in hyperextension, allowing the olecranon process to translate anterior to the trochlea. Divergent elbow dislocation occurs when the radius and ulna separate during concomitant ulnohumeral joint dislocation. Typically, the mechanism is from a high-energy trauma leading to joint disruptions and tearing of the interosseous ligament, annular ligament, and distal radioulnar joint.5

Elbow dislocations occur in 3 stages, with the site of injury progressing in a circular fashion from the lateral to the medial elbow, referred to as the Circle of Horii.3 Stage 1 is characterized by partial or complete disruption of the lateral collateral ligament complex, manifested by posterolateral rotatory instability. In stage 2, further disruption anteriorly and posteriorly results in an incomplete elbow dislocation with perching of the coronoid process on the humeral trochlea. Stage 3 is subdivided into 3 components: 3A describes disruption of all of the soft tissues around and including the posterior part of the medial collateral ligament except for the anterior bundle; 3B features complete disruption of the medial collateral ligamentous complex of the elbow; and 3C implies significant instability of the elbow such that the joint can dislocate even with immobilization of the elbow in a cast with 90° of flexion.3

Clinical Findings

Most patients with elbow dislocations present with extreme pain and loss of range of motion. On examination, the
deformity is obvious and can be confirmed by disruption of the equilateral triangle from the tip of the olecranon to the distal humeral epicondyles. The distal radioulnar joint and interosseous membrane should be examined for tenderness. Forearm supination and pronation is typically retained because this motion comes from the proximal and distal radioulnar joints but is not preserved with divergent dislocations. With classic acute posterior dislocations, the elbow is fixed in some degree of flexion, whereas anterior dislocations present with the elbow in extension.

Careful assessment of the distal neurovascular function should be performed and documented immediately because a delay in treatment may lead to irreversible arm damage. Neurologic problems occur in approximately 20% of all dislocations, with neuropraxia usually resolving after a short period. The ulnar nerve is most commonly involved; radial nerve injuries occur more frequently if an associated radial head fracture exists. The distal radial and ulnar pulses must be checked, although the presence of a pulse may not exclude a significant arterial injury because collateral circulation may account for reperfusion. This is particularly true with the presence of an associated compartment syndrome.

**IMAGING**

**Radiography**

Trauma radiographs typically consist of standard anteroposterior, lateral, and oblique views obtained with the elbow in internal and external rotation. A lateral radiograph of a properly positioned elbow will allow a line to be drawn tangentially to the anterior cortex of the humerus that extends through the middle one-third of the capitellum and for a line to be drawn along the long axis of the radius that bisects the capitellum. Disruption of the radiocapitellar line is most commonly seen with elbow dislocation (Figure 1). All images should be closely examined for evidence of a fracture, and the lateral radiograph should be evaluated for the presence of an elbow effusion, which may be the only radiographic sign of an underlying fracture or serious soft tissue injury.

If dynamic elbow instability is suspected, varus and valgus stress views may provide significant information. Often, the only sign of dislocation is a subtle osteochondral change identified on the lateral radiograph. It is important to identify a rupture of the medial collateral ligament after elbow dislocation because those injuries have a higher risk of persistent valgus instability. This is diagnosed using a stress radiograph with the elbow under a valgus load, but it may be painful for the patient immediately after the traumatic incident.

**Computed Tomography**

Computed tomography is typically reserved for complex dislocations to better define the anatomy, accurately classify the injury patterns, and evaluate for intra-articular bodies (Figures 2, 3). Three-dimensional, surface-rendered computed tomography images are of particular benefit in preoperative decision making and planning.
Magnetic Resonance Imaging

The superior soft tissue contrast of magnetic resonance imagine (MRI) allows simultaneous evaluation of bone and soft tissue, allowing for assessment of the static and dynamic stabilizers and making accurate diagnoses possible using a single examination (Figure 4). Its multiplanar capabilities and superior tissue contrast afford detailed evaluation of complex anatomy. Proper coil selection, pulse sequence parameters, and patient positioning enhance the ability of MRI to demonstrate subtle ligamentous injuries and regional osseous and soft tissue structures, including those not easily visualized during surgery. Imaging is best performed with the patient in the supine position, with the arm at the side, the elbow fully extended, and the forearm in supination.

Elbow MRI has proven to be highly accurate in assessing the degree of medial and lateral collateral ligamentous injury and can detect signal hyperintensity in sprains and discontinuity of some or all of the fibers with ligamentous partial- or full-thickness tearing. Although the ulnar collateral ligament may avulsed either proximally or distally, disruptions of the midsubstance of the ligament account for a majority of traumatic injuries. Cartilaginous injury may be detected, particularly involving the radiocapitellar joint in the case of an acute valgus overload and in the posterior margin of the trochlea with valgus extension overload. Cartilage-sensitive, fast spin-echo MRI should be evaluated to exclude the presence of such lesions, and a careful search for intra-articular bodies should be performed.

**MANAGEMENT**

Once an elbow dislocation is diagnosed clinically or by radiograph, immediate reduction using intravenous or regional anesthesia is necessary within 3 hours of injury to improve the patient’s outcome and decrease the risk of neurovascular complications. Reduction is commonly achieved with the patient lying in a prone position with his or her elbow hanging off the edge of the bed; a physician applies traction and slight supination to the forearm while attempting to distract and unlock the coronoid process from the olecranon fossa by applying pressure to the posterior aspect of the olecranon. If several attempts at reduction are unsuccessful, then reduction while under general anesthesia or operative reduction should be attempted. It is essential to obtain radiographs after reduction to assess for stability and to guide further management because simple and complex dislocations are managed differently.

**Simple Dislocation**

The management of simple elbow dislocations is determined by the degree of stability after reduction. The range of motion, including forearm rotation, should be normal and smooth. The reduction and congruency of the joint should be exact on radiographs. If the elbow is stable after reduction, then it should be placed in a sling or hinged brace and managed with functional treatment, defined as early active movement within the limits of pain. Early mobilization has been found to improve results, including range of motion and pain, while not increasing the risk of redislocation or late instability.
If the elbow subluxes or dislocates in extension after reduction, then stability should be assessed under dynamic fluoroscopy with the forearm in pronation. If this restores stability, then a hinged brace or splint with an extension block should be applied. The forearm is placed in full pronation and active flexion is encouraged. Extension is gradually increased on a weekly basis to achieve full extension over 3 to 4 weeks. If more than 45° of flexion is required to maintain elbow reduction, repair of the collateral ligaments with or without the combination of an external fixator should be considered, even though insufficient evidence exists to support surgical management of simple elbow dislocations in adults. The available evidence from trials comparing surgery vs conservative treatment does not suggest that the surgical repair of elbow ligaments for simple elbow dislocation improves long-term function.

In general, simple uncomplicated elbow dislocations have excellent results in half of all cases, with full range of motion, absent pain, and a stable joint after reduction. Although closed reduction with short-term immobilization is a universally accepted treatment method for simple elbow dislocations that has excellent functional scores, complicated elbow dislocations can still be associated with significant limitations in joint movements and a majority of patients do not consider themselves fully recovered.

**Complex Dislocations**

Elbow fracture-dislocations commonly involve the bony stabilizers (radial head, coronoid process, olecranon process, and distal humeral articular face) of the elbow joint. The fundamental goal in the management of elbow fracture dislocations is the restoration of the osseous articular restraints. Therefore, the majority of complex dislocations are treated with open reduction and internal fixation (ORIF) (Figure 5). Fracture healing is given precedence over elbow mobilization because chronic instability is more difficult to treat than stiffness. Ligaments should be directly repaired and secured to their osseous origins. If the ligaments are torn beyond repair, reconstruction is required using a free tendon graft, such as the palmaris longus or the plantaris tendon. Assessment of elbow stability is essential following ORIF of complex elbow dislocations; signs of instability include redislocation, positive pivot shift test, and positive valgus/varus stress testing.

The postoperative management of unstable elbows following ORIF consists of a period of plaster immobilization in most cases. More detailed management guidelines are described for each specific type of complex dislocation. In complex dislocations involving the radial head, the basic treatment principle is to first reduce the dislocation and then determine the extent to which the ulnohumeral articulation is inherently stable. In type 1 fractures, if the elbow is stable to within 45° or 50° of extension, then it is placed in a splint at 60° of flexion to be worn for 1 to 2 weeks. Full flexion and extension is then allowed as tolerated usually without protection. In type 2 fractures, treatment consists of ORIF and repair of the medial ligament (Figure 5). In type 3 fractures, the comminuted radial head fracture is excised acutely and the ligaments are repaired. Immobilization following such treatment is necessary to ensure that a redislocation does not occur, but the elbow should not be immobilized for more than 4 weeks to avoid poor outcomes.

Elbow fracture-dislocations involving the distal humerus are uncommon in adults and usually involve an avulsion fracture of the medial epicondyle. Isolated fractures of the capitellum are often more complex and involve the lateral epicondyle, trochlea, and posterior aspect of the distal part of the humerus. Failure to adequately restore the fracture through the lateral trochlea lip may compromise elbow stability, function, and durability. Management generally requires ORIF of all displaced fractures and immobilization for all nondisplaced fractures.

Elbow fracture-dislocations involving the coronoid process are rare and difficult to treat. Type 1 fractures can be managed conservatively with immobilization using a sling. In type 2 fractures with stable reduction, motion within the stable arc of a hinged brace is allowed. If posterior displacement occurs with less than 40° to 45° of flexion, the ulnohumeral joint must be stabilized with internal fixation. If concern about stability still exists, the elbow may need to be neutralized by the application of a hinged external fixator applied for 3 to 6 weeks to eliminate the dynamic forces that are applied to the fracture site. The external fixator allows motion of the ulnohumeral joint, whereas a 2- to 3-mm distraction gap is placed on the ulna, protecting the articulation. In a large noncomminuted fracture (type 3A), internal fixation with 1 or 2 screws is sufficient, whereas fixation using a heavy suture and possibly a buttress plate is necessary in severely comminuted coro-
noid fractures (type 3B). Maintenance of the ulnohumeral relationship by a distraction device is critical in type 3 fractures.

Finally, an elbow fracture-dislocation that involves a fracture of the coronoid process and the radial head is termed the terrible triad due to marked instability and associated complications. This specific combination of injuries can rarely be treated conservatively with splint immobilization because redislocation is common. Operative treatment with external fixation or transfixation of the elbow allows motion while eliminating force on the radial head and coronoid. The principle of the surgical management is based on 2 main objectives: restoration of bony stabilizing structures (radial head and coronoid process) with internal fixation and lateral collateral ligament reconstruction, with select cases requiring repair of the medial collateral ligament and adjuvant hinged external fixation.

References