PERSPECTIVE

Because injuries in the region of the elbow have a high potential for complications and residual disability, early recognition of neurovascular and soft tissue complications improves the outcome in many of these injuries. Coordination between the emergency physician and the treating orthopedist is essential, particularly because new options are emerging for many of these injuries.

Anatomy

The humerus is a long bone that articulates proximally at the shoulder with the glenoid of the scapula to form the glenohumeral joint and distally with the radius and ulna to form the three-way elbow joint. The upper end of the humerus, the humeral head, is shaped like a near hemisphere. Adjacent to the humeral head are two bony prominences, the greater and lesser tuberosities. Between these, on the anterolateral aspect of the humerus, runs the bicipital groove. The shaft of the humerus extends from the upper border of the insertion of the pectoralis major muscle superiorly to the groove. The shaft of the humerus extends from the upper border of the insertion of the pectoralis major muscle superiorly to the supracocondylar ridges posteriorly. The shaft is cylindrical on cross section in the upper half and tends to become flat in the distal portion in an anteroposterior direction. Three surfaces are described. The anterolateral surface presents the deltoid tuberosity for the insertion of the deltoid muscle, and below this is the radial sulcus, which transmits the radial nerve and profunda artery. The anteromedial surface forms the floor of the intertubercular groove. It enters the antecubital fossa and bifurcates into the anterior compartment. The posterior surface is the origin for the triceps and contains the spiral groove.

The bony anatomy of the distal humerus and elbow is diagrammed in Figure 52-1. The distal end of the humerus tapers into two columns of bone, the medial and lateral condyles. Between the condyles, the bone thins, and the recess created is the coronoid fossa. The more proximal nonarticular portions of the condyles are the epicondyles. Just proximal to the epicondyles, the supracocondylar ridges run up each side of the humerus. Collectively, these areas serve as points of origin for the muscles of the forearm. The wrist flexors originate from the medial epicondyle, and the wrist extensors originate from the lateral epicondyle. Fractures of the distal humerus often result in fragment displacement because of the pull of these strong forearm muscles on attachment sites.

The bony anatomy of the elbow allows for two complex motions: flexion-extension and pronation-supination. The elbow is composed of three articulations within a common joint cavity. The trochlea is the articular surface of the medial condyle and articulates with the deep trochlear notch of the ulna formed by the olecranon inferriorly and posteriorly and by the coronoid process anteriorly. This articulation permits hinged flexion and extension at the elbow. The articular surface of the lateral condyle is the capitellum, which permits the radius to hinge on the elbow. The proximal radius consists of a disklike head supported by the smooth narrow radial neck. The radial head articulates with the capitellum of the humerus and with the radial notch of the ulna.

Four ligamentous structures are important in evaluating elbow injuries (Fig. 52-2). The radial head is held in place by the annular ligament and the adjacent radial collateral ligament. Rotation of the radial head within the confines of the fibrous annular ligament permits pronation and supination. In addition, the ulnar collateral ligament and anterior capsule add stability to the joint. Fracture or dislocation of the joint may severely damage the ligamentous structures.

The soft tissues of the upper arm are divided into two compartments: anterior and posterior. The anterior compartment contains three muscles—the biceps brachii, the brachialis, and the coracobrachialis—and the brachial artery, median nerve, musculocutaneous nerve, and ulnar nerve. The only two structures contained in the posterior compartment are the triceps brachii muscle and the radial nerve.

The neurovascular structures of this area are shown in Figure 52-3. The brachial artery, which is the continuation of the axillary artery, travels with the median nerve in the anterior compartment of the upper arm. It enters the antecubital fossa and bifurcates into the radial and ulnar arteries.

One important anatomic variation is the presence of a supracondylar process (in approximately 2.5% of cases) just proximal to the medial epicondyle (Fig. 52-4). When the supracondylar process is present, the median nerve and brachial artery must traverse behind this process, then forward between a fibrous band connecting the process to the epicondyle. Median nerve symptoms may develop if this process is fractured or if an injury causes swelling in the vicinity of the supracondylar process.

The radial nerve leaves the axilla and spirals posteriorly around the humerus between the heads of the triceps in the radial groove. It enters the anterior compartment of the arm laterally, crossing the elbow anterior to the lateral epicondyle to innervate the extensors of the wrist and fingers. Because of its close relationship to the shaft of the humerus, the radial nerve is particularly susceptible to injury with midshaft humeral fractures. Fixed in position by the intermuscular septum, the nerve may become trapped between fracture fragments, particularly when reduction is attempted.

The ulnar nerve runs parallel to the median nerve. Halfway down the arm, it penetrates the intermuscular septum to run along the medial aspect of the triceps muscle in the posterior compartment. It enters the forearm by passing behind the medial condyle. Fractures in the vicinity of the medial condyle place this nerve at considerable risk for injury.
Three elbow bursae are clinically important. The olecranon bursa is located between the olecranon and the skin posterior to the joint. This bursa provides protective padding and allows smooth movement of the skin over the olecranon. Because of its position, it is often a site of traumatic or infectious bursitis. The radiohumeral bursa provides for smooth movement over the radial head with supination and pronation. A third bursa cushions the biceps tendon from the radius during flexion of the elbow. As evident by the descriptions of these structures, all are vulnerable when significant skeletal injury occurs in this region.

**CLINICAL FEATURES**

**History**

A history detailing musculoskeletal complaints includes a description of any pain in terms of quality, duration, location, palliative and provocative activities, severity, and radiation. Past medical history and occupational factors are important in chronic problems. For traumatic injuries, a detailed account of the incident is important because it provides information about the mechanism of injury and some estimate of the energy delivered. Subjective complaints of numbness or weakness distal to the injury are important clues to possible neurovascular injury. In dealing with injuries in children, the possibility of nonaccidental trauma needs to be considered.

**Physical Examination**

Inspection of the upper extremity is important, but manipulation of the painful extremity should be minimized and postponed to the end of the examination whenever possible. This is especially important with children. A great deal of useful information can
be gathered by simple inspection and comparison with the contralateral limb. The position in which the extremity is held should be noted. In children with extension-type supracondylar fractures, the arm is held at the side and has a characteristic S-shaped configuration, whereas with flexion-type supracondylar fractures, the forearm is supported with the opposite hand with the elbow flexed to 90 degrees. Patients with radial head subluxation have the elbow only slightly flexed and hold the forearm in pronation.

Deformity is evidence not only of significant injury, but also of the type of injury. Increased prominence of the olecranon suggests a posterior dislocation of the elbow or extension supracondylar fracture, whereas loss of the normal olecranon prominence indicates anterior dislocation or flexion supracondylar fracture. The extremity also should be inspected for wounds that may indicate an open fracture, evidence of swelling, and change in color of the distal extremity.

One special aspect of the elbow examination is the determination of the carrying angle, the normal outward angulation of the extended forearm at the elbow. This angle allows the long axes of the humerus and forearm to become superimposed when the elbow is flexed (Fig. 52-5). This angle varies from 5 to 20 degrees in adults, with men having less angulation than women. Measurement of the carrying angle is helpful in assessing subtle supracondylar fractures in children. As shown in Figure 52-6, lines drawn parallel to the shafts of the humerus and ulna intersect to form an angle with a mean measurement in children of 13 degrees, although this angle varies widely. A difference in carrying angles of greater than 12 degrees (from one side to the other for a particular individual) is associated with fractures. However, the carrying angle is used primarily for assessing the adequacy of reduction or the results of fracture healing rather than for acute diagnosis, because it is difficult for children to fully extend the arm during the initial evaluation for this measurement to be obtained.

The vascular status of the extremity is of highest priority. Brachial, radial, and ulnar pulses should be palpated and documented. The ulnar pulse is not palpable in some normal people. Although brisk capillary refill suggests adequate tissue perfusion, a handheld Doppler device often is required to evaluate major vessel flow if significant swelling is present or if the pulses are not palpable. Any suggestion of arterial injury requires immediate investigation. Poor perfusion may result from direct arterial injury, compression or kinking in the instance of significant displacement from a fracture or dislocation, or compartment syndrome. Passive extension of the fingers produces severe pain in the forearm in the presence of flexor (volar) compartment ischemia. Of the five Ps associated with arterial occlusion (pain, paresthesia, pallor, pulselessness, and paralysis), pain is the only dependable early sign of compartment syndrome. Orthopedic consultation and measurement of compartment pressures should be considered for patients who have pain disproportionate to their injury. Other modalities used to evaluate vascular status while the orthopedist is being called in include measurement of the ankle-brachial index and color flow Doppler.

Neurologic evaluation includes assessment of the radial, median, and ulnar nerves. After evaluation of neurovascular function, all bony prominences are palpated, and areas of tenderness are noted carefully and documented. Crepitus and bony deformities are unusual in the absence of fracture or dislocation. Bony crepitus associated with pain in an acutely injured limb is virtually diagnostic of a fracture. The radial head specifically should be palpated for tenderness, and any noticeable effusion should be noted.

The range of motion of the elbow in all planes (i.e., flexion-extension and pronation-supination) should be determined and documented. With the forearm supinated, the normal range of motion is 0 degrees in full extension to 150 degrees in full flexion. A mild degree of hyperextension is normal in some individuals and should be symmetrical. With the elbow flexed at 90 degrees and the thumb facing up, the forearm normally supinates and pronates 90 degrees. Range-of-motion testing may be impossible with severe injuries and can be postponed until after radiographic evaluation, avoiding manipulating fractures and dislocations. Any manipulation of the extremity is followed by reexamination because neurovascular injury has been reported with nearly every therapeutic procedure.

Radiographic Findings

Whereas most elbow and humerus injuries are evaluated radiographically, occasionally history and clinical examination alone are sufficient (e.g., radial head subluxations). Although clinical
decision rules for the elbow have not been validated, it is reason-
able to perform radiography when there is significant limitation in range of motion, obvious deformity, joint effusion, or signifi-
cant tenderness over any of the bony prominences or the radial head. In the absence of these, radiographic studies are optional. The threshold for radiography should be much lower in pediatric populations owing to the presence of open growth plates and limitation in the physical examination with the exception of children with obvious nurserymaid's elbow (radial head subluxation).

Routine views of the elbow include at least the anteroposterior and lateral views, with consideration given to obtaining oblique views for certain injuries. Anteroposterior and oblique views are taken with the elbow extended. The lateral view is taken with the elbow in 90 degrees of flexion and the thumb pointing upward. Positioning of the elbow is important because anything but a true lateral view makes accurate interpretation of soft tissue findings and alignment difficult. Corresponding views of the opposite extremity may be helpful, especially for children, but should not be ordered routinely.

Many fractures in the elbow region are obvious on plain film, with cortical disruption, angulation, or displacement of fragments. Minor fractures can be subtle and may be missed. Special attention to the contour of the radial head and the fat pads reduces the risk of missing fractures. The normal cortex of the radius is smooth and has a gentle continuous concave sweep. If consistent with history and physical findings, any disruption of this smooth arc is considered evidence of fracture. Abnormalities within the soft tissues on elbow films are particularly important and may be the only radiographic sign of a fracture. Normally, fat surrounding the proximal elbow joint is hidden in the concavity of the olecranon and coronoid fossae. The normal elbow has only a narrow strip of lucency anteriorly (the anterior fat pad), and a posterior fat pad is not visible on radiographs. Injuries that produce intra-articular hemorrhage cause distention of the synovium and displace the fat out of the fossa, making the posterior fat pad visible on lateral radiographic views. The anterior fat pad also is altered by this swelling, becoming more prominent and taking the shape of a spinnaker sail from a boat: “sail sign” (Fig. 52-7). In the setting of trauma, more than 95% of patients with the “posterior fat pad” sign have intra-articular skeletal injury. These soft tissue findings occur even with subtle fractures, and when they are present in the setting of trauma, an occult fracture is considered to be present even when not visible on radiographs. In adults, a radial head fracture is implied, whereas in children a supracondylar fracture is the more likely underlying injury. In the absence of trauma, the presence of a fat pad suggests other causes of effusion (e.g., gout, infection, bursitis). The fat pad signs may be absent in fractures where the injury is severe enough to rupture the capsule.

The anterior humeral line is a line drawn on a lateral radiograph along the anterior surface of the humerus through the elbow. Normally, this line transects the middle third of the capitellum (Fig. 52-8). With an extension supracondylar fracture, this line either transects the anterior third of the capitellum or passes entirely anterior to it. The abnormal relationship between the anterior-humeral line and capitellum may be the only evidence of a minimally displaced supracondylar fracture and is a presumptive finding of a fracture.

Another diagnostic aid in evaluating radiographs of possible supracondylar fractures in children is the determination of Baumann’s angle. As shown in Figure 52-9, the intersection of a line drawn on the anteroposterior film through the midshaft of the humerus and the growth plate of the capitellum defines an angle of approximately 75 degrees. In normal children, Baumann’s angle is the same in both elbows, and it has been suggested that a comparison between the injured and uninjured sides be used to assess the accuracy of reduction. An increase in Baumann’s angle indicates medial tilting of the distal fragment. Alteration in Baumann’s angle is thought to predict the final carrying angle when the fracture heals, although there is controversy regarding its reliability.

Radiographic evaluation of the elbow in children is difficult because of the presence of multiple ossification centers (Fig. 52-10). Table 52-1 lists the typical age of first appearance and fusion of ossification centers, which gives rise to the CRITOE acronym:

- Capitellum
- Radial head
- Internal (medial) epicondyle
- Trochlea
- Olecranon
- External (lateral) epicondyle
**Table 52-1  Ossification Centers of the Elbow: CRITOE**

<table>
<thead>
<tr>
<th>OSSIFICATION CENTERS</th>
<th>AGE OF APPEARANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capitellum</td>
<td>1-2</td>
</tr>
<tr>
<td>Radial head</td>
<td>4-5</td>
</tr>
<tr>
<td>Internal (medial) epicondyle</td>
<td>4-5</td>
</tr>
<tr>
<td>Trochlea</td>
<td>8-10</td>
</tr>
<tr>
<td>Olecranon</td>
<td>8-9</td>
</tr>
<tr>
<td>External (lateral) epicondyle</td>
<td>10-11</td>
</tr>
</tbody>
</table>

**Figure 52-7.** A, Anterior and posterior fat pads on lateral study (arrows). B, The anterior fat pad is normally a thin radiolucent stripe; the posterior fat pad is now visible. C, An effusion displaces both fat pads. This posterior fat pad is now visible.

**Figure 52-8.** A, A line drawn down the anterior surface of the humerus on a lateral film should transect the middle of the capitellum. B, With an extension supracondylar fracture, the line passes more anteriorly. (From Simon R, Koenigsknecht S: Emergency Orthopaedics: The Extremities, 2nd ed. Norwalk, Conn, Appleton & Lange, 1987.)

**Figure 52-9.** Baumann's angle as measured on anteroposterior film. (From Worlock P: Supracondylar fractures of the humerus. J Bone Joint Surg [Br] 68:755, 1986.)

**Figure 52-10.** Secondary growth centers of the elbow. (1) Capitellum; (2) radial head; (3) medial epicondyle; (4) trochlea; (5) olecranon; (6) lateral epicondyle. (From Townsend DJ, Bassett GS: Common elbow fractures in children. Am Fam Physician 53:2031, 1996.)
Comparison views of the uninjured elbow are often helpful in distinguishing fractures from the normal epiphyses and ossification centers.

Management

General management principles for humerus and elbow injuries are similar to those for other orthopedic injuries. Limb-threatening conditions, such as vascular injury, are addressed immediately by reduction of fractures or surgical exploration. The limb should be splinted in a position of comfort, and appropriate analgesia should be provided. Antibiotics are administered for suggested open fractures. Prolonged immobilization of the elbow frequently results in stiffness of the joint that requires extensive physiotherapy to restore normal function. For this reason, range-of-motion exercises are begun early in the convalescent period, often before a fracture has healed completely.

Fractures in Children

Injuries in the region of the shaft of the humerus and about the elbow fall into several categories (Box 52-1). Emergency department (ED) management varies with location and type of fracture or dislocation. Supracondylar fractures of the humerus in children are usually described according to the Gartland classification (Box 52-2).

Fractures of the Shaft of the Humerus

Pathophysiology

Fractures of the humeral shaft commonly result from a direct blow to the arm, such as occurs during a fall or motor vehicle collision. Severe twisting of the arm or a fall on an outstretched hand can also produce this type of fracture. Fractures produced by violent muscle contraction, such as occurs when a javelin or baseball is thrown, also are reported. Motion of the humerus is controlled by several muscle groups, which also influence the fracture pattern of the humeral shaft. If the fracture is located proximal to the attachment of the pectoralis major, the proximal fragment of the humerus abducts and rotates internally owing to the action of the rotator cuff, whereas the distal fragment is displaced medially by the pectoralis major (Fig. 52-11A). If the fracture occurs below the pectoralis major insertion but above the deltoid insertion, the distal fragment is displaced laterally by the deltoid muscle, and the proximal fragment is displaced medially by the pull of the pectoralis major, latissimus dorsi, and teres major muscles (Fig. 52-11B). In fractures occurring distal to the deltoid insertion, the proximal fragment is abducted by the deltoid, and the distal fragment is proximally displaced (Fig. 52-11C). The shaft of the humerus most commonly fractures in the middle third in a transverse fashion (Fig. 52-12).

Clinical Features

The patient reports localized pain, often severe in nature. The arm is visibly swollen and cannot be used. When a fracture is complete, bony crepitus is felt in the shaft of the humerus with any manipulation of the arm. The arm may be shortened or rotated, depending on the displacement of the fracture fragments. When the fracture is incomplete, the skeleton is tender to palpation and swollen, but not otherwise deformed. A complete neurovascular examination is indicated. Attention should be directed to radial nerve function because injury to this nerve is the most common complication associated with humeral shaft fractures.

Radiographic findings are confirmatory. Studies routinely should include the shoulder and elbow joints. The humerus is a common site for benign tumors, unicameral cysts, and primary bone malignancies. The humeral shaft also is a common site for metastatic disease. Thinning of the cortex and abnormal osteoblastic or osteoclastic activity are evidence of a pathologic fracture (see Fig. 52-12). These fractures do not heal without concomitant treatment of the underlying pathologic condition.

Management

Closed fractures that are isolated injuries are treated conservatively with a high degree of success. Elaborate attempts at fracture reduction and external immobilization are unnecessary and sometimes detrimental to healing. Humeral shaft fractures remain surrounded by a richly vascularized envelope of muscle so that fracture reduction is accomplished most easily with the aid of gravity and muscle balance. Fractures that are nondisplaced or minimally displaced are immobilized by adding a coaptation, or “sugar-tong,” splint, to the sling and swathe (Fig. 52-13). This is accomplished by first padding the extremity, then carrying a long plaster splint from the lateral side of the shoulder, down the lateral aspect of the upper arm, around the elbow with the elbow flexed, and then up the inner aspect of the arm to the axilla. The sugar tong is wrapped in an elastic bandage, and a sling is used to support the arm in 90 degrees or less of flexion. The weight of the

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**Box 52-1** Classification of Fractures

I. Humerus fracture
   A. Shaft of the humerus fractures
      1. Supracondylar
         a. Extension
         b. Flexion
      2. Transcondylar
         a. Extension
         b. Flexion
   3. Intercondylar
      a. Nondisplaced
      b. Separated
      c. Separated and rotated
      d. Combination with articular surfaces
   4. Condylar
      a. Medial
      b. Lateral
   5. Articular surface
      a. Capitellum
      b. Trochlea
   6. Epicondylar
      a. Medial
      b. Lateral
II. Radial head fracture
   A. Nondisplaced
   B. Displaced
   C. Comminuted
III. Ulnar fracture
   A. Olecranon fracture
   B. Coronoid fracture

**Box 52-2** Gartland Classification for Supracondylar Fractures in Children

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Minimal or no displacement</td>
</tr>
<tr>
<td>II</td>
<td>Displacement of the fracture, but with the posterior cortex intact</td>
</tr>
<tr>
<td>III</td>
<td>Displaced, no cortical contact</td>
</tr>
<tr>
<td>IIIA</td>
<td>No rotation of the fracture</td>
</tr>
<tr>
<td>IIIB</td>
<td>Rotation present</td>
</tr>
</tbody>
</table>

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A loop at the wrist. Angulation is corrected by placing the plaster loop on the dorsal aspect of the cast (to reduce lateral angulation) or on the volar side of the cast (to reduce medial angulation). Anterior or posterior angulation is corrected by altering the length of the sling apparatus (Fig. 52-14). Care is taken not to make the cast too heavy because this would distract fracture fragments. The hanging cast has the disadvantage of requiring gravity for traction and requires that the patient remain upright at all times, including during sleep, a situation that many patients find intolerable.

Figure 52-11. Influence of muscles on displacement of humeral shaft fractures based on fracture location. A, Fracture is proximal to the attachment of the pectoralis major muscle. B, Fracture is between insertion of the pectoralis major and deltoid muscles. C, Fracture is distal to the deltoid insertion.
Neurovascular examination should be repeated and documented after the application of any splint or cast, because loss of nerve function from entrapment of the nerve between fragments can occur after these interventions.

The use of open reduction and internal fixation (Fig. 52-15) has been more frequent recently and is necessary in certain circumstances, including open fractures, presence of multiple injuries that preclude mobilization, bilateral fractures, poor reduction, poor patient compliance, failure of closed treatment, and fractures through pathologic bone. Isolated radial nerve palsy usually is assumed to be a neurapraxia and is managed nonoperatively. Exploration and internal fixation are indicated, however, if the radial nerve palsy develops after manipulation because this is highly suggestive of nerve entrapment.

All patients with humeral shaft fractures should be referred to an orthopedic surgeon for close follow-up monitoring. When dependency casting is used, follow-up evaluation within 24 to 48 hours is recommended to be certain that the alignment has been maintained. Emergent referral to an orthopedist is recommended for patients with evidence of radial nerve injury, severely displaced or comminuted fractures, open fractures, or fractures associated with forearm fractures in the same extremity.

Complications

The most common complication, radial nerve injury, occurs in 20% of humerus fractures. This nerve injury is most often a benign neurapraxia that resolves spontaneously in most patients, although recovery may take several months. Patients should be advised of this possible complication, with instructions to contact their orthopedist or return to the ED for evaluation if this occurs. Radial nerve injuries associated with penetrating trauma or open fractures are likely to be permanent and usually warrant operative exploration. Median and ulnar nerve injuries are rarely seen, usually in the presence of penetrating trauma. Injuries to the brachial artery occur rarely, and, if clinically suggested, angiography or other vascular studies should be considered.

Fractures of the Distal Humerus

Supracondylar Fractures

Distal humerus fractures that occur proximal to the epicondyles are called supracondylar fractures. This type of fracture is almost exclusively an injury of the immature skeleton, with a peak incidence in children 5 to 10 years old. This injury rarely occurs after age 15 and accounts for approximately one half of all elbow fractures and one third of pediatric limb fractures. In children, the tensile strength of the collateral ligaments and joint capsule of the elbow is greater than that of bone. In adults, the reverse is true, and a posterior elbow dislocation is sustained instead. Supracondylar fractures are classified as either extension or flexion fractures, depending on the mechanism of injury and the displacement of the distal fragment. Of these injuries, 98% are of the extension type.

Extension Supracondylar Fractures

Pathophysiology. Extension supracondylar fractures occur as a consequence of a fall on the outstretched arm when the elbow is either fully extended or hyperextended (e.g., a fall off the
angulation of the sharp distal end of the proximal fragment into the antecubital fossa, endangering the brachial artery and median nerve (Fig. 52-17). In most cases, however, the brachialis muscle protects the anterior neurovascular structures from injury.

**Clinical Features.** A child with a complete fracture comes to the ED holding the upper extremity immobile in extension to the side, with a typical S-shaped configuration and tenderness and swelling in the region of the elbow. Prominence of the olecranon attached to the posteriorly displaced distal fragment is similar to that seen with posterior dislocation of the elbow. When an incomplete supracondylar fracture exists, the diagnosis may be less obvious, with an elbow effusion as the only clinical sign. A careful neurovascular examination is essential. Although palpation is useful in determining the site of injury, the examining physician should avoid manipulation of the injury to elicit crepitus because movement can cause further neurovascular damage. Alleviating pain often facilitates the examination.

**Diagnostic Strategies.** On radiographic examination, the distal fragment is often displaced on the lateral view. This displacement is most likely to occur with a complete fracture wherein the muscle activity results in proximal migration of the distal fragment. Because this fracture occurs in children, 25% of supracondylar fractures are of the greenstick variety, with the posterior cortex remaining intact. Subtle changes (e.g., the presence of a posterior fat pad or an abnormal anterior humeral line) may be the only radiographic clues to the presence of a fracture (Fig. 52-18). In displaced fractures on the anteroposterior view, the distal fragments may be displaced either medially or laterally in relationship to the humerus. Often, with minimally displaced fractures, the fracture line is transverse and not visible on the anteroposterior view. Based on radiographic findings, extension supracondylar fractures are classified into three types: type I, minimal or no displacement; type II, displaced fracture, posterior cortex intact; and type III, totally displaced fracture, anterior and posterior cortex disrupted.

**Management.** Nondisplaced fractures (type I) are immobilized primarily for comfort and protection because they are inherently stable. They are treated in a splint or cast flexed to 90 degrees with the forearm in neutral rotation. Protected active range of motion is begun in approximately 3 weeks. Even without definite radiographic findings, a child with localized tenderness consistent with a supracondylar fracture should be splinted and referred for follow-up examination within 24 to 48 hours. A radiographic study performed a few weeks after the injury may reveal periosteal new bone formation in the supracondylar region.

Minimally displaced (type II) fractures that are stable after reduction can be treated with splinting or casting with the elbow flexed. Some authors recommend flexion to 110 to 120 degrees for this injury. This position uses the intact posterior periosteum as a tension band to hold the reduction; however, if swelling or circulatory obstruction prevents this much flexion, it cannot and should not be used. The greater the flexion at the elbow, the greater is the chance of vascular impairment. When swelling peaks at 24 to 48 hours, the risk of vascular obstruction and compartment syndrome is the greatest. Occasionally, these injuries must be pinned percutaneously to maintain stability, especially if a significant rotational component is present. Percutaneous pinning of fractures after reduction has grown in popularity in recent years.

Type III totally displaced fractures generally are the result of more severe injuries that produce more swelling than type I or type II injuries. Displacement necessitates the reestablishment of length, increases the chance of varus deformity, and increases the chances of interposed soft tissues and neurovascular injury. For all these reasons, patients with type III fractures require immediate orthopedic consultation in the ED and should be admitted to the hospital for frequent neurovascular checks and closed versus open fixation and percutaneous pinning.

“monkey bars”). The elbow is likely to be in the latter position at the time of the fall because ligamentous laxity, with hyperextension of the joints, is a normal phenomenon in younger children. With the forearm acting as a lever, the ground reaction produces a moment of force at the elbow (Fig. 52-16). Ultimately the distal humerus fails anteriorly in the supracondylar area. The strong action of the triceps tends to pull and displace the distal fragment in a posterior and proximal direction. There may be anterior

![Figure 52-15. Midshaft humerus fracture: A, before and B, after open reduction and internal fixation.](image-url)
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While traction is maintained, the elbow is gently flexed to just beyond 90 degrees (Fig. 52-19C). Angulation is corrected to a normal carrying angle.

Medially displaced supracondylar fractures are most prone to tilt into cubitus varus and are immobilized with the forearm pronated to tighten the brachioradialis and common extensor muscles. This procedure closes the fracture laterally. The less common laterally displaced fracture is immobilized in supination to close the fracture medially.

Only one attempt should be made at manipulation. Multiple attempts increase the likelihood of neurovascular injury and swelling. If reduction is unsuccessful, simple traction on the extended elbow may restore vascular supply. When reduction is performed, follow-up radiographs are obtained to ensure adequate reduction. Neurovascular function is checked at frequent intervals. Cylinder casts are not applied initially because they increase the risk of forearm ischemia; a posterior plaster splint provides safe and adequate immobilization.

Patients with type I fractures can be discharged safely from the ED with instructions to elevate the extremity, apply ice, and have a follow-up evaluation in 1 to 2 days. Fractures that require manipulation usually warrant admission to the hospital to ensure compliance and for neurovascular monitoring.

ischemia of the forearm is a dreaded complication but is rare in this era (reported incidence <0.5%).

The most common complication is the loss of the carrying angle, resulting in a cubitus varus, or “gunstock,” deformity. Measurement of Baumann’s angle after reduction is predictive of the final carrying angle. Cubitus varus has been reported previously in 25 to 60% of patients, depending on the treatment method used. This incidence has decreased significantly (<10%) with the use of percutaneous pinning. The distal humerus has little capacity to remodel because only 20% of the growth of the bone derives from the distal physis. A small amount of extension or flexion deformity produces little disability, has the greatest chance of remodeling, and is not a major cosmetic concern. Valgus or varus deformities, being in the coronal plane, have little or no chance of remodeling. Although cubitus varus is not a significant functional disability, it presents a significant cosmetic problem. In most cases this complication can be corrected at a later time by an osteotomy.

Nerve injuries occurred in 7% of 4520 fractures compiled from 31 major reported series. The incidence increases to a range of 19 to 49% with increasing severity of fracture displacement. The interosseous nerve is the most commonly injured, followed by the radial, median, and ulnar nerves. Most deficits seen at the time of injury are neurapraxias that resolve with conservative therapy. Ten percent of children lose the radial pulse temporarily, most often as a result of swelling and not direct brachial artery injury. Reducing the fracture, avoiding flexing the elbow more than 90 degrees, and elevating the arm help prevent secondary obstruction to arterial flow. Compartment syndrome, or Volkmann’s ischemic contracture, as a result of prolonged

**Figure 52-17.** Supracondylar fractures, extension and flexion. (Adapted from Simon R, Koenigsknecht S: Emergency Orthopaedics: The Extremities, 2nd ed. Norwalk, Conn, Appleton & Lange, 1987.)

**Figure 52-18.** Supracondylar fracture (arrow) with anterior and posterior fat pads visible.

**Figure 52-19.** Steps in reduction of displaced supracondylar fracture (see text).
management. Motor function returns within 7 to 12 weeks, whereas recovery of sensation may take more than 6 months.15

Flexion Supracondylar Fractures

Pathophysiology. Flexion-type injuries are much less common, with a reported frequency of 1 to 10%, accounting for 2% of all supracondylar fractures in a large pooled series of patients.16 The mechanism of injury is a direct blow to the flexed elbow. Energy is transferred from the posterior aspect of the proximal ulna to the distal humerus, resulting in a supracondylar fracture with anterior displacement of the distal fragment. As the fragment displaces, the periosteum is torn posteriorly.

Clinical and Radiographic Features. The elbow is usually held in flexion rather than with the extremity in the S-shaped configuration seen in extension-type injuries. In displaced fractures, the normal olecranon process is not palpable, in contrast to the increased prominence of the olecranon seen with extension injuries. Radiographically, these injuries can be classified into three types, similar to extension injuries:

- Type I fracture—undisplaced or minimally displaced
- Type II fracture—incomplete fracture; anterior cortex intact
- Type III fracture—completely displaced; distal fragment migrates proximally and anteriorly

Plain films may reveal a simple increase in the anterior angulation of the distal supracondylar fragment or gross displacement of the distal fragment proximal and anterior to the distal end of the proximal fragment. In the latter case, the distal end of the proximal fragment protrudes posteriorly. A line down the anterior humeral shaft intersects the capitellum either normally or posteriorly in these fractures, depending on whether there is anterior displacement.17

Management. When the posterior periosteum is torn, the anterior periosteum functions as a tension band with the arm in extension. In type I fracture, the periosteum is minimally displaced. These injuries do not need to be immobilized in extension. The elbow can be comfortably flexed and should be immobilized in a splint as with extension injuries. Type II and III injuries should be referred to an orthopedist emergently. Type II injuries are manipulated into extension, then held either in a long arm cast or with percutaneous pins. Type III injuries often require open reduction (Fig. 52-20).

Complications. The most common complication is injury to the ulnar nerve by posterior displacement of the proximal fragment. The radial and median nerves are rarely injured. Stiffness of the elbow also may occur, especially after open reduction. Cubitus valgus may occur but is not as cosmetically problematic as cubitus varus.

Transcondylar Fractures

Transcondylar (or dicondylar) fractures have a fracture line, either transverse or crescent shaped, that passes through both condyles within the joint capsule just proximal to the articular surface (Fig. 52-21). As with supracondylar fractures, two types have been described—extension and flexion—based on the position of the elbow when fractured. Extension types are the most common. The mechanism of injury is similar to that for supracondylar injuries. In contrast to supracondylar fractures, however, the injury is more common in elderly individuals with fragile, osteoporotic bone. These fractures generally are difficult to treat because the small distal fragment possesses little extra-articular bone, and only a small amount of bone contact is available for union.19 During healing, excessive callus may form in the olecranon or coronoid fossae with residual loss of motion. Orthopedic consultation should be immediately obtained for these injuries.

Intercondylar Fractures

Intercondylar fractures are usually T-shaped or Y-shaped fractures with variable degrees of separation of the condyles from each other and from the proximal humerus fragment (Fig. 52-22). The distal portion of the fracture extends to the articular surface of the distal humerus. These injuries are rare and generally are seen in adults in their 50s and 60s.17 The usual mechanism of injury is direct trauma to the elbow that drives the olecranon against the humeral articular surface and splits the distal end.

Clinical and Radiographic Features. Patients with intercondylar fractures complain of pain at the elbow, which on examination is tender to palpation. Good-quality anteroposterior and lateral radiographic views are essential in evaluating fracture displacement and comminution (Fig. 52-23). Computed tomography may be used to delineate fracture patterns further. Neurovascular complications are not common with these injuries.
Management. Treatment of intercondylar fractures is difficult and complicated. The goal of treatment is to reestablish articular congruity and alignment and to begin active motion as soon as possible, most often through open reduction with rigid internal fixation. Closed treatment is typically restricted to elderly patients, patients with medical conditions that prohibit surgery, and certain patients with nondisplaced fractures. These injuries all should be referred to an orthopedic surgeon emergently. As with supracondylar fractures, manipulation should be avoided unless limb-threatening ischemia is present. Traction across the elbow with the arm extended is helpful in restoring blood flow to an ischemic forearm.

Complications. Historically, loss of elbow joint function is the most common complication reported, although this now can be largely avoided with optimal surgical technique. Any method of treatment that requires prolonged immobilization is likely to result in fibrosis or ankylosis of the joint. Neurovascular complications are rare.

Lateral Condyle Fractures in Children

Lateral condyle fractures are the second most common fractures involving the elbow in children, after supracondylar fractures. The fracture has an age distribution similar to that of supracondylar fracture and occurs after a fall on the outstretched hand, with a varus stress applied to the extended arm.

Clinical and Radiographic Features. Tenderness and swelling are noted over the lateral aspect of the elbow. In general, children exhibit less swelling than with supracondylar fractures, and neurovascular compromise is uncommon. Diagnosis is usually made on standard anteroposterior and lateral views, although an oblique view also may be helpful. These fractures are notoriously difficult to diagnose because fractures with minimal displacement are difficult to see radiographically and are often misdiagnosed as supracondylar humerus fractures.

Management. Nondisplaced fractures are treated nonoperatively with a cast, whereas fractures with any displacement require closed or open reduction with percutaneous pin fixation for 3 to 4 weeks. Operative treatment is indicated if displacement is greater than 2 mm; otherwise, conservative treatment is sufficient.

Complications. The risk of neurovascular compromise is much lower than with supracondylar humerus fractures. Fractures diagnosed and treated in a timely manner should have few complications, although historically, nonunion, cubitus varus or valgus, and fishtail deformity (avascular necrosis) have been reported.

Medial Condyle Fractures in Children

Medial condyle fractures are rare, comprising 1 to 2% of pediatric elbow fractures. These fractures are type IV Salter-Harris injuries with physeal injury a possible outcome. The mechanism of injury is believed to be a valgus force on the extended elbow.

Clinical and Radiographic Features. The patient has tenderness and swelling over the medial aspect of the elbow. Anteroposterior, lateral, and oblique films may show the fracture in older children, but because the trochlea does not ossify until about age 9, plain films in younger children do not show the fracture. Magnetic resonance imaging (MRI) may be necessary to confirm the diagnosis in these patients.

Management. Operative treatment is indicated if displacement is greater than 2 mm; otherwise, conservative treatment is sufficient.

Complications. A study of 21 patients with medial condyle fractures revealed a 33% complication rate. Complications included loss of reduction requiring reoperation, avascular necrosis, nonunion, and cubitus varus. Most minimally displaced fractures healed uneventfully.
Condylar Fractures in Adults

Condylar fractures are rare in adults and typically involve the articular surface and the nonarticular portion of the distal humerus, including the epicondyle (Fig. 52-24). The status of the lateral trochlear ridge is the key to analyzing humeral condyle fractures. It may be involved with either medial or lateral condylar fractures and, when incorporated into the distal fragment, is far more likely to result in instability.

Pathophysiology. Lateral condylar fractures are uncommon, although more common than fractures of the medial condyle. The mechanism of injury is either a direct blow to the lateral aspect of the flexed elbow or a force that results in adduction and hyperextension with avulsion of the lateral condyle. Medial condylar fractures are rare and result from either a direct blow to the apex of the flexed elbow or a fall on the outstretched arm with the elbow forced into varus.

Clinical and Radiographic Features. The presentation of condylar fractures is similar to that of other distal humerus fractures, with swelling, tenderness, and crepitus localized over either the medial or the lateral elbow. On palpation, independent motion of the involved condyle may be appreciated. In lateral condylar fractures, findings may be accentuated with movement of the radius. On radiographic examination, lateral condylar fractures show a widening of the intercondylar distance. The distal fragment is often displaced, most commonly posteriorly and inferiorly. Because of the location of the ulnar nerve, it is imperative to test its function when this fracture is present. Medial condylar fractures are associated with tenderness over the medial condyle and pain with flexion of the wrist against resistance. On radiographic examination, displaced distal fragments tend to be anterior and inferior because of the pull of the forearm flexors.

Management. Immediate treatment depends on radiographic findings. For undisplaced or minimally displaced condylar fractures, immobilization of the flexed elbow in a long arm posterior plaster splint is sufficient. For lateral condylar fractures, the forearm should be supinated and the wrist extended to relieve the tension on the extensor muscle attachments. For medial condylar fractures, the reverse is true (i.e., the forearm should be pronated and the wrist flexed). For fractures displaced more than 3 mm, surgical fixation is required.

Complications. Complications include nonunion, restricted range of motion, joint instability, cubitus valgus or varus deformity, arthritis, and ulnar neuropathy. Because of the high rate of complications, orthopedic consultation should be sought for all condylar fractures.

Articular Surface Fractures

Capitellum Fractures

Pathophysiology. Fractures of the capitellum and trochlea typically occur together, usually as a result of posterior dislocation of the elbow, with isolated fractures being rarer. Injury to the capitellum occurs when the patient falls on an outstretched hand, jamming the radial head upward, similar to the motion of a piston, shearing off the capitellum into the radial fossa. Because the capitellum has no muscular attachments, the fragment may remain nondisplaced. More often the fragment is displaced (usually anteriorly, but occasionally posteriorly). Because of this mechanism, a radial head fracture also may be present and should be clinically suspected.

Clinical and Radiographic Features. The development of significant signs and symptoms may be delayed with capitellum fractures. Eventually, swelling within the capsule results in severe pain that manifests as well-localized tenderness on examination. Flexion of the elbow increases pain. A true lateral plain film usually shows the fragment lying anterior and proximal to the main portion of the capitellum (Fig. 52-25).

Management. Treatment begins in the ED with a posterior splint, ice packs, elevation, compression, and analgesia. Accurate anatomic alignment, rigid internal fixation, and early mobilization are prerequisites for a good functional result.24 Fractures of the articular surfaces can be treated nonsurgically only if radiographs show perfect anatomic alignment.

Complications. Complications include post-traumatic arthritis, avascular necrosis of the fracture fragment, and restricted range of motion.
Trochlea Fractures

Pathophysiology. Isolated fractures of the trochlea are exceedingly rare because of the structure’s protected position deep within the elbow joint. The shearing force of the ulna against the trochlea is associated more commonly with posterior elbow dislocation.

Clinical Features. The elbow is painful, with an effusion and limited range of motion because this is an intra-articular injury. On the radiograph a fragment is visible lying on the medial side of the joint, just distal to the medial epicondyle, and signs of joint effusion are visible. The fracture may extend into the distal portion of the medial epicondyle.

Management. Nondisplaced fractures may be treated with a posterior splint for 3 weeks, followed by early range-of-motion exercises. Displaced fractures should be treated operatively; fragments that can be internally fixed are repaired, whereas small fragments are excised. Immobilization should be minimized to 10 to 14 days.

Epicondyle Fractures

Most epicondylar fractures involve the medial epicondyle. Medial epicondylar fractures are most common in children and adolescents and often involve the apophysis, which is the last ossification center to fuse in the distal humerus, usually after age 15. Fractures through this ossification center usually occur in adolescence and constitute 11% of pediatric elbow fractures.

These are not Salter–Harris injuries because the apophysis is involved rather than the physis. Because the lateral epicondyle is almost level with the flattened outer surface of the lateral condyle, it has only minimal exposure to a direct blow, and fracture is extremely rare.

Pathophysiology. Medial epicondyle injuries occur from a variety of mechanisms. First, avulsion fractures are associated with posterior elbow dislocations in patients younger than 20 years in 30 to 55% of cases. Second, repetitive valgus stress (as with throwing a ball) results in eventual avulsion fracture of the epicondyle (Little Leaguer’s elbow). Another reported cause of fracture separation of the medial epicondyle, usually in adolescent boys, is arm wrestling. Violent muscular forces associated with a shifting center of gravity during this activity seem to produce an avulsion just before closure of the epiphyseal plate. Finally, a direct blow to the medial epicondyle can cause this injury.

Clinical and Radiographic Features. The elbow is held in flexion, and any movement is resisted. Isolated fractures are associated with focal tenderness over the medial epicondyle. Use of the forearm flexors increases pain because their attachment is along the medial epicondyle. Ulnar nerve function should be evaluated. When the fracture is associated with a posterior dislocation, the examination reveals a prominent olecranon.

Simple fractures of the medial epicondyle are extra-articular injuries with limited soft tissue injury. They generally do not produce a fat pad sign on the lateral radiographic view of the elbow. A posterior fat pad or significant swelling of the joint should suggest concurrent injuries, such as elbow dislocation.

Careful radiographic evaluation is especially important because fracture fragments may migrate into the joint space. If the fragment is overlying the joint line on radiographic examination, it should be considered intra-articular (Fig. 52-26). Radiographic detection of the intra-articular fragment is often difficult. Associated ulnar nerve palsy may be present with an entrapped fragment. Fragments may be difficult to see on radiographs, and a true anteroposterior view is difficult to obtain because of severe pain on extension. In an adolescent patient, there is a tendency to confuse the normal radiolucent epiphyseal growth plate with a fracture. In addition, minimally displaced fractures may be difficult to appreciate with radiographs. Comparison films of the uninjured elbow may be necessary. If dislocation is present, repeat radiographs taken after reduction should be evaluated for fragment location.

Management. If the fracture fragment is minimally displaced (<5 mm), treatment with a posterior splint is appropriate. To minimize distraction of the fragment by the forearm flexors, the elbow and wrist are flexed with the forearm pronated.

Treatment of displaced fractures is controversial. In the past, the amount of displacement often dictated the need for surgery. Results of operative and nonoperative treatment seem to be good, however, regardless of the degree of displacement. Some experts advocate surgery for patients who participate in high-performance athletic activities that involve the injured extremity, but controlled studies are lacking. Intra-articular fragments that cannot be removed from the joint by manipulation are an indication for surgery. Immediate orthopedic consultation should be sought for these injuries. The rare lateral epicondylar fracture in adults was previously treated with immobilization, but more recent experience indicates that operative management is more successful.
Olecranon Fractures

Pathophysiology. Fractures of the olecranon may result from one of several mechanisms. Most commonly, a direct blow as a result of a fall, a motor vehicle or motorcycle crash, or an assault produces this injury. Such injuries are frequently comminuted. Less commonly, indirect force applied by forceful contraction of the triceps while the elbow is flexed during a fall can cause a transverse or oblique fracture through the olecranon. A combination of direct and indirect forces is believed also to cause some of these fractures. Olecranon fractures occur in adults and less commonly in children. The anatomic integrity of the olecranon is similar to the way intact patellar function is necessary for extension of the knee.

Clinical Features. Physical findings may include tenderness and pain over the olecranon, a palpable separation at the fracture site, or the inability to extend the elbow against force. This last finding indicates complete discontinuity of the pulling mechanism and the consequent failure of triceps function. The neurovascular status should be examined, with special attention given to the ulnar nerve distribution, because this structure is most vulnerable to injury in this location. Loss of sensation over the palmar aspect of the fifth digit and hypothenar eminence or motor weakness in the interossei muscles of the hand suggest ulnar nerve injury.

Diagnostic Strategies. Lateral radiographic views are most helpful. In addition to the fracture, the degree of comminution, the extent of articular surface disruption, and the amount of displacement in the 90-degree flexion position should be noted. Non-displacement in this position indicates that the triceps aponeurosis is intact, and prolonged immobilization is unnecessary. Displacement of more than 2 mm is considered an indication for surgery (Fig. 52-28A). A fracture line that increases in separation with flexion of the elbow also is considered a displaced fracture. When this fracture is associated with elbow dislocation, the plane of instability is located through the fracture site and the radiohumeral joint, resulting in posterior displacement of the proximal fragment of the ulna and anterior dislocation of the radius and ulna as a unit (Fig. 52-28B).

Management. Undisplaced fractures can be treated conservatively on an outpatient basis with ice, compression, immobilization in 45 to 90 degrees of flexion, and analgesia. Follow-up films should be done at frequent intervals to ensure that subsequent displacement does not occur. Range-of-motion exercises can be started within 3 weeks in many cases.

Displaced fractures or fracture-dislocations require open reduction and internal fixation, and patients should be referred immediately to an orthopedic consultant. Displaced fractures in elderly patients sometimes are treated conservatively, but this should be left to the discretion of the consultant. Orthopedic referral also is necessary when ulnar nerve symptoms are present. These symptoms occur in 10% of patients, and in most cases the injury is an ulnar contusion that resolves spontaneously. The long-term outcome of treated olecranon fractures in adults is usually favorable with a low incidence of subsequent arthritis.

Radial Head and Neck Fractures

Pathophysiology. Radial head and neck fractures, in general, are produced by an indirect mechanism, typically a fall on an outstretched hand. The radius transmits the force upward, driving the
range-of-motion exercises (within 24-48 hours). Aspiration of the hemarthrosis and injection of 0.5% bupivacaine into the joint space may give dramatic relief of pain and improve the range of motion.\(^3\) However, a recent prospective randomized study found no benefit to bupivacaine instillation compared with simple aspiration.\(^1\) Most patients with this injury recover well in 2 to 3 months. A few do poorly, however, with long-term pain, contracture, or inflammation.

Type II injuries usually are treated similarly, with aspiration, instillation of bupivacaine, and immobilization in the ED, followed by a trial period of range-of-motion exercises. In these cases, aspiration of the joint and instillation of bupivacaine not only relieve pain but also allow testing of the range of motion to identify entrapped fragments. Radial head excision sometimes is performed later if the patient fails to improve. Early excision is advised for type II fractures when a mechanical block is present and for most type III fractures. Long-term functional results after radial head excision are acceptable in most patients, although a few have some functional disability after this procedure.\(^3\) Type IV injuries are treated for the elbow dislocation as described next and for the specific radial head lesion.

**DISLOCATION AND SUBLUXATION**

**Elbow Dislocation**

Because of its anatomic structure, the elbow is inherently subject to mechanical instability, and dislocations are common. The elbow is second only to the shoulder as the most commonly dislocated large joint. Elbow dislocation is a term usually used to describe a disruption of the relationship between the humerus and the olecranon. In general, the radius and ulna, bound together firmly by the annular ligament and interosseous membrane, displace as a unit. Most classifications refer to the abnormal position of the ulna relative to the humerus. The elbow most often dislocates posteriorly, although it may dislocate anteriorly, medially, or laterally (Fig. 52-30). A dislocation also may occur between the radius and ulna, and such dislocations rarely occur concurrently with the ulnohumeral type. The latter are termed divergent dislocations.

Dislocation of the elbow requires considerable energy, and it is not surprising that a significant number of dislocations are associated with fractures of adjacent bony structures. A
approximately 90 degrees and immobilized with a posterior plaster mold. The neurovascular status should be rechecked. Postreduction radiographs are important to avoid missing concomitant fractures of the coronoid process or radial head or, in children, separation of the medial epicondylar apophysis.

Postreduction management includes immobilization in a posterior splint with the elbow in as much flexion as circulation allows. The arm is suspended in a sling. Circular casting should be avoided initially. Patients can be discharged with instructions to apply ice, elevate, and watch for signs of vascular impairment. Patients should not be discharged until and unless they can follow such instructions. If the elbow is stable after reduction, gentle range-of-motion exercises may be initiated in 3 to 5 days. Unstable joints may require either prolonged immobilization in

fracture-dislocation injury is referred to as a complex elbow dislocation. Immediate reduction of these dislocations is imperative to relieve pain and to prevent circulatory embarrassment or cartilaginous damage.

**Posterior Elbow Dislocation**

**Pathophysiology.** The mechanism of injury is a fall on the outstretched hand or wrist, the elbow being either extended or hyperextended at the time of impact. A valgus stress usually also occurs. The resultant forces lever the ulna from the trochlea and produce the dislocation.

**Clinical and Radiographic Features.** Patients hold the elbow in flexion at approximately 45 degrees and have marked prominence of the olecranon. Some elbow dislocations reduce before examination in the ED, presenting a confusing picture. In any case, significant diffuse tenderness and swelling are present. Neurovascular status is checked because brachial artery and median nerve injuries have been described. Neurovascular injury may occur from numerous mechanisms, including the initial traction, local swelling, and entrapment during reduction. Repeat examinations are mandatory.

A radiographic example of elbow dislocation before reduction is provided in Figure 52-31. Radiographic evaluation is crucial before manipulation to rule out fractures that can mimic dislocation on examination. Also, several fractures commonly occur in conjunction with dislocation, and these need to be identified and treated when present. These include fractures of the distal humerus, radial head, and coronoid process.

**Management.** Orthopedic consultation is usually not necessary to proceed. Reduction should be attempted immediately, especially if there is neurovascular compromise. Intra-articular injection of local anesthetic may provide adequate analgesia to allow for closed reduction. Procedural sedation is very helpful and often required to facilitate reduction. Rarely is a regional block or general anesthesia needed. Posterior dislocations are reduced with an assistant immobilizing the humerus and applying countertraction while traction is applied to the distal forearm. The ideal position is for the elbow to be flexed at 30 degrees with the forearm supinated while distal traction is applied. When the capitellum slides over the coronoid process, a coupling sound occurs as the articular surfaces mesh. If reduction is unsuccessful with this technique, the physician should apply downward pressure at the proximal forearm and apply pressure behind the olecranon while maintaining in-line traction. This downward force may help “unlock” the coronoid process, which may be trapped in the olecranon fossa. The joint is gently moved through its normal range of motion to check stability. If stable, the elbow is flexed to

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Figure 52-30. Elbow dislocation, posterior and anterior. (Adapted from Simon R, Koenigsknecht S: Emergency Orthopaedics: The Extremities, 2nd ed. Norwalk, Conn, Appleton & Lange, 1987.)

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Figure 52-31. Characteristic posterior dislocation of elbow, lateral (A) and anteroposterior (B) views.
the presence of ligamentous instability or internal fixation for instability associated with fracture.\textsuperscript{36}

Complications. The most serious complication of elbow dislocation is vascular compromise. Severe disruption results in injury to the brachial artery in 5 to 13\% of cases.\textsuperscript{37} Vascular injury should be sought when a wide opening between the tip of the olecranon and the distal humerus is palpated or seen on a radiograph. The presence of distal pulses is not proof of an intact artery, and if a question of vascular compromise exists, emergent vascular studies or consultation is indicated. Median nerve function after reduction should also be reported. Loss of median nerve function after reduction should prompt immediate orthopedic consultation. Recurrent dislocation of the elbow is rare.

Medial and Lateral Dislocations

Medial and lateral elbow dislocations are produced by a mechanism similar to that in posterior dislocations, with a vector of force displacing the ulna and radius as a unit either medially or laterally. The anteroposterior view is the key to determining these dislocations. Reduction is carried out with the arm in slight extension but otherwise is similar to that for posterior dislocation. Care should be taken not to convert these to posterior dislocations during reduction. Complications and aftercare are the same as for posterior dislocations.

Anterior Elbow Dislocation

Pathophysiology. Anterior dislocations are rare and occur as a result of a blow from behind to the olecranon while the elbow is in the flexed position. Severe associated soft tissue trauma is present, including avulsion of the triceps mechanism or vascular disruption. These dislocations are frequently open.

Clinical Features. The upper arm appears shortened and the forearm elongated. The elbow is fully extended, and the forearm is supinated. The olecranon fossa is palpable posteriorly.

Management. Reduction of closed injuries is performed with distal traction of the wrist and a backward pressure on the forearm while the distal humerus is grasped. A click usually indicates that reduction has been achieved. These injuries have a higher incidence of vascular impairment than the more common posterior dislocation, but ulnar nerve injuries are unusual.\textsuperscript{34} Emergent orthopedic referral is advised and is mandatory for open injuries or when vascular disruption is suggested.

Radial Head Subluxation

Pathophysiology

Subluxation of the radial head is a common injury, representing more than 20\% of upper extremity injuries in children. Children aged 1 to 4 years are most often affected, although cases have been reported in children 6 months to 15 years of age. Girls are affected more commonly than boys, and the left arm is more commonly affected than the right.\textsuperscript{39} This injury is called nursemaid’s elbow because it results from a sudden longitudinal pull on the forearm while the child’s arm is in pronation. Stretching of the annular ligament allows fibers to slip between the capitellum and the head of the radius, resulting in an inability of the child to supinate the arm. By the age of 5, the annular ligament becomes thick and strong and thus is far less likely to tear or be displaced.

Clinical and Radiographic Features

The classic history, present approximately half of the time,\textsuperscript{40} is that of the forearm being pulled while in pronation with the elbow extended. Other mechanisms include direct trauma to the elbow or a twisting motion of the arm. In children younger than 6 months, the mechanism of subluxation involves rolling over in bed, which may trap the involved forearm under the body with resulting longitudinal traction on the joint. Clinically, the arm is held in passive pronation, with slight flexion at the elbow. The child is unable or unwilling to move the arm. Resistance to supination and tenderness on direct palpation over the head of the radius are present. Swelling, ecchymosis, and deformity are absent. Examination should include inspection and palpation of the entire extremity, including the clavicle.

When the history is suggestive of radial head subluxation, radiographs are not necessary and are rarely positive. If there is swelling or deformity, if there is an uncharacteristic history, if the child does not resume use of the arm after reduction, or if there is a possibility of nonaccidental trauma, appropriate radiographic studies are recommended. If palpation of the forearm, wrist, or humerus away from the elbow elicits reproducible tenderness, radiographs should be taken to exclude other diagnoses.

Management

Reduction may be attempted in children with typical presentations and is safe even when the classic history is absent. Supination-flexion is the method most commonly used in the past. Reduction is achieved by supination of the forearm while slight pressure on the radial head is applied with the examiner’s thumb. In one continuous motion, the elbow is supinated and flexed with gentle traction applied. A click often, but not always, is felt as the radial head reduces (Fig. 52-32). A second technique of reduction, hyperpronation, has a significantly higher reported success rate of reduction on the first attempt.\textsuperscript{41} With the hyperpronation method, the child’s elbow is supported with moderate pressure applied to the radial head. The examiner then grips the child’s distal forearm and hyperpronates the forearm, resulting in a click felt over the radial head (Fig. 52-33).

Many patients are asymptomatic within 5 to 10 minutes; 90\% of patients regain use of the arm within 30 minutes. Hearing or palpating a click is associated with success. It is a good idea for the physician to leave the room and for parents to distract the child to show return of normal function. A fearful child often does not use even the successfully reduced limb. If function does not return within 24 hours, the patient should be reevaluated. After successful reduction, no additional treatment, immobilization, or activity reduction is necessary. Parents and caregivers should be instructed to avoid excessive traction on the child’s forearm to prevent recurrent radial head subluxation. The recurrent radial head subluxation rate is approximately 20\%.\textsuperscript{42} Most of these injuries are unintentional on the part of the caregiver, but inflicted injury should be considered in suggestive cases.

SOFT TISSUE DISORDERS

Epicondylitis (Tennis Elbow)

Pathophysiology

Tennis elbow is a term first introduced in the 1880s to describe an inflammatory process that involves the radiohumeral joint or lateral epicondyle of the humerus. It is a common exercise-related syndrome, and the mechanism is thought to be repetitive pronation and supination of the forearm. The actual pathologic nature of this syndrome is unclear. Radiohumeral bursitis or synovitis, tendinitis of the common extensor tendon, periostitis of the lateral epicondylole, and entrapment by scar tissue of the radial nerve all have been suggested as culprits in this syndrome. Histologically, the abnormality has been described as angiofibroblastic
hyperplasia, a term subsequently modified to angiofibroblastic tendinosis. The cause has been theorized to be a degenerative process because of the paucity of acute inflammatory cells seen histologically.43 Medial tennis elbow and posterior tennis elbow have been reported, the former involving the pronator teres and flexor carpi radialis insertions and the latter involving the triceps tendon. The following discussion pertains to lateral tennis elbow.

Clinical and Radiographic Features

Whatever the cause, the onset is usually gradual. Patients report dull pain over the lateral aspect of the elbow, increased by grasping or twisting motions. Tenderness is located over the lateral epicondyle or radiohumeral joint. Supination and pronation against resistance may be painful. Pain can be shown by stretching the wrist extensors. To test this, the elbow is extended, the forearm pronated, and the wrist fully dorsiflexed.

Radiographic findings may be normal, although with chronicity, calcifications may be present over the lateral epicondyle. Characteristic MRI findings also have been described, although MRI is not indicated emergently.

Management

Traditional treatment includes protection, rest, ice, compression, elevation, and medication. Initial therapy includes avoidance of the inciting activity and immobilization with a sling. Nonsteroidal anti-inflammatory drugs are often used, but their efficacy probably is limited to their analgesic rather than their anti-inflammatory properties. Injection of a corticosteroid at the point of tenderness provides some pain relief in most patients.43,44 Because corticosteroids weaken collagen, premature resumption of heavy loading of the tendon at the lesion should be avoided, as should injection directly into the tendon. Patients with pain that persists despite treatment and a rehabilitation program should be referred for possible surgery.45 Modification of athletic technique is recommended after the symptoms subside.

Olecranon Bursitis

Pathophysiology

Although several bursae are located in the elbow region, the olecranon bursa is the one most often involved in an isolated pathologic process. Olecranon bursitis commonly is caused by repetitive

Figure 52-32. Subluxation of the radial head. Method of reduction: (1) Apply pressure to radial head, (2) supinate the forearm, and (3) flex elbow, in one continuous motion.

Figure 52-33. Hyperpronation method of radial head subluxation reduction: A, Support elbow with pressure to radial head, then hyperpronate the arm distally (B).
minor trauma, such as leaning on the elbow during work activities. It also may result from an inflammatory process, such as gout or an infectious process within the bursa (septic bursitis). Septic olecranon bursitis occurs most commonly in patients engaged in work that predisposes to repetitive trauma to the elbow, such as gardening or plumbing.

Clinical Features

Patients usually have progressive pain, tenderness, and swelling over the olecranon. Some patients with septic bursitis have an abrupt onset instead, with a rapid increase in pain over a few hours. On examination, the septic bursa is typically swollen, hot, erythematous, and tender. Flexion often is limited by pain brought on by tightening of the skin over the inflamed bursa. Minor breaks in the skin, frank abrasions, or healing lacerations over the bursa may be present. Noninfectious bursitis usually manifests with less warmth and erythema. The skin is intact, and swelling may be the only finding. The most important aspect of evaluation is the differentiation of a septic process from a benign inflammatory one. This differentiation may be difficult on clinical grounds because considerable overlap exists in the histories and physical findings.

Diagnostic Strategies

If doubt exists, aspiration of the bursa should be performed and the aspirate sent for crystals, white blood cell count, Gram’s stain, and cultures. Unless the aspirate is frankly bloody, traumatic nonseptic olecranon bursitis usually has a leukocyte count lower than 1000 cells/mm³, whereas septic bursal fluid usually has a count higher than 10,000 white blood cells/mm³.

Management

Aspiration is diagnostic and therapeutic because relief of pressure relieves some of the pain. In cases of purulent bursitis, the bursa should be drained, and appropriate antibiotics should be begun in the ED. Pending culture results, empirical antibiotics should include coverage for routine skin organisms as well as methicillin-resistant *Staphylococcus aureus* (MRSA). Bursitis refractory to aspiration and appropriate antibiotics may require incision and drainage. Noninfectious bursitis can be managed with a compression dressing, ice, nonsteroidal anti-inflammatory medications, and avoidance of the inciting activity. Patients who have had their bursa aspirated should be rechecked within 24 to 48 hours to verify culture results and monitor their response to treatment.

Biceps Tendon Rupture

Pathophysiology

Biceps tendon rupture occurs most commonly in the proximal portion of the long head of the biceps. It is most common in middle-aged athletes or physical laborers who sustain repetitive microtrauma to the tendon. Patients experience a snapping sound and pain in the anterior shoulder during strenuous activities that produce rapid loading of the muscle. Rupture also occurs distally, usually as an avulsion from the insertion on the radial tuberosity, although ruptures at the musculotendinous junction occasionally occur. Rupture of the distal biceps tendon occurs almost exclusively in men, most commonly between the ages of 40 and 60, and most often involves the dominant arm.66-47 The inciting event is usually an unexpected extension force applied to the arm flexed at 90 degrees. The pathophysiology of tendon rupture is poorly understood, although tendon rupture generally occurs in the setting of underlying tendinosis. Biceps tendon tears are becoming more common in players in the National Football League (NFL), most commonly in offensive linemen.48 Diabetes, chronic renal failure, systemic lupus erythematosus, rheumatoid arthritis, and steroid or fluoroquinolone therapy all may result in tendinosis. Smoking has been shown to be strongly associated with distal biceps tendon rupture.49

Clinical Features

The diagnosis is usually obvious. In proximal tendon rupture, the patient usually has a visible defect at the top of the bicipital groove with bunching of the muscle distally. Flexing of the elbow produces pain at the proximal insertion. Flexion remains intact, however, because the short head of the biceps usually maintains its integrity. With distal ruptures the patient reports pain and tearing in the antecubital region. Visible deformity and a palpable defect of the biceps muscle belly are present with weakness of elbow flexion and supination. If the tendon is completely ruptured, there is a bunching up of the muscle, and this effect is accentuated when the patient attempts flexion. Radiographs are not revealing and usually not necessary. MRI may be useful when a partial rupture is suggested.

Management

All patients require urgent referral to an orthopedist. Early anatomic repair of complete ruptures usually is recommended. Partial ruptures occasionally respond to conservative treatment but also may require surgical repair. The arm should be splinted and the patient advised to apply ice and be given analgesics while awaiting orthopedic consultation.

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**KEY CONCEPTS**

- Clinical decision rules for the elbow joint have not been validated. Radiographs should be obtained when there is limitation in range of motion, obvious deformity, joint effusion, or significant tenderness or crepitus over any of the bony prominences or the radial head. In the absence of these, it would seem appropriate to omit radiographs in adults. The threshold for imaging should be lower in pediatric patients owing to the presence of open growth plates and limitations to the physical examination.
- In children with wrist pain and traumatic mechanism of injury, the absence of a clear-cut explanation for the pain (e.g., no abnormal radiographic findings) should prompt consideration of an elbow injury causing referred pain to the wrist.
- In the setting of trauma, more than 90% of patients with the posterior fat pad sign of the elbow have intra-articular skeletal injury. In adults, a radial head fracture is implied, whereas in children, a supracondylar fracture is the probable underlying injury. In the absence of trauma, other causes of effusion (e.g., gout, infection, or bursitis) should be considered.
- The most common complication, radial nerve injury, occurs in 20% of humerus fractures. This is most often a benign neurapraxia that resolves spontaneously in most patients, although recovery may take several months. Radial nerve injuries associated with penetrating trauma or open fractures are likely to be permanent and usually warrant operative exploration.
- Generally the radius and ulna, bound together firmly by the annular ligament and interosseous membrane, displace as a unit and typically dislocate posteriorly, although anterior, medial, or lateral dislocations may occur.
- Radiographic studies are not required when the history suggests radial head dislocation (nursemaid’s elbow). If there
is swelling or deformity, if there is an uncharacteristic history, if the child does not resume use of the arm after reduction, or if there is a suggestion of child abuse, appropriate radiographic studies should be obtained.

- Biceps tendon rupture occurs almost exclusively in men, most commonly between ages 40 to 60, most often involving the dominant arm, and usually subsequent to an unexpected extension force applied to the arm flexed at 90 degrees. Smoking, diabetes, chronic renal failure, systemic lupus erythematosus, rheumatoid arthritis, and steroid or fluoroquinolone therapy may predispose to this injury. This injury is increasing in frequency in NFL players, usually in offensive linemen, and may become more common in college athletes as well.

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The references for this chapter can be found online by accessing the accompanying Expert Consult website.
References


