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Challenging and Elusive Orthopedic Injuries: Diagnostic and Treatment Strategies for Optimizing Clinical Outcomes

Part I: Upper Extremity Fractures and Dislocations

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The majority of orthopedic injuries encountered by the emergency physician are diagnosed promptly and treated appropriately. In these cases, the mechanism of injury is well delineated, the symptoms are strongly suggestive of a specific diagnosis, the physical examination pinpoints the nature of the injury, and routine radiographic studies identify the expected lesion. However, there is a spectrum of orthopedic injuries—including subtle fractures and difficult-to-identify dislocations—that presents a formidable diagnostic challenge for the emergency physician.

These orthopedic "pitfalls" frequently involve such areas as the wrist, shoulder, and hand, anatomic regions where trauma can produce a diverse, unusual, and sometimes unexpected range of clinically signficant dislocations and fractures that are extremely difficult to pinpoint during the initial emergency department (ED) encounter. Unfortunately, delays in diagnosis can lead to non-union of fractures, neurovascular compromise, functional impairment, chronic deformity, and the need for surgical correction of unnecessary complications.

Despite the assessment and treatment challenges presented by these entities—among them, posterior and inferior glenohumera dislocations, fracture/dislocations of the wrist bones, and carpometacarpal dislocations—there are step-by-step strategies for minimizing misdiagnosis, reducing medico-legal risks, and optimizing clinical results. Almost without exception, this requires a thorough understanding of the clinical anatomy, maintaining a high index of suspicion for specific fractures and/or dislocations based on mechanism of injury, knowing how to interpret the physical examination, and customizing radiographic studies (including number and angles of different views) to increase the sensitivity of this diagnostic tool. In this first part of a two-part article, the authors elucidate diagnostic and treatment pitfalls for orthopedic injuries involving the upper extremity. A detailed supplement providing clinico-radiographic correlations is provided for use in the heat of battle.

—Editor

Shoulder Injuries

Posterior Glenohumeral Dislocation. As a rule, acute shoulder dislocations are correctly diagnosed and appropriately managed in the ED. The majority of these shoulder dislocations, however, are anterior.[1] Acute traumatic posterior dislocation is rare and, despite its infrequent occurrence, it is the most commonly missed joint dislocation in the body. In fact, more than 50% of posterior dislocations are incorrectly diagnosed and/or poorly managed at the time of the initial encounter, and even emergency physicians may find this orthopedic condition problematic.[1,2] Reflecting the widespread problem of initial mismanagement of posterior glenohumeral dislocation, the orthopedic literature is replete with discussions outlining the treatment of chronic, unreduced posterior shoulder dislocations. From a clinical perspective, the diagnosis is often missed because the examining physician does not have a sufficiently high index of suspicion to seek out the classic physical findings. However, even if the clinician does not initially consider the problem and misses the diagnosis on physical examination, appropriate radiographs will clearly delineate the problem. Put simply, these injuries should be suspected in all patients who present with shoulder injuries and in all individuals who have suffered a seizure or electrical shock.[3]

History. When obtaining the history in a patient with shoulder trauma, it is important to obtain specific information about the mechanism of injury and the position of the arm at the time of injury. In this regard, posterior glenohumeral dislocations generally occur when the arm is forward flexed and slightly internally rotated. The dislocation can occur when an axial load is applied in this position. Hitting a heavy punching bag or striking the dashboard with the arm extended to the front are examples of mechanisms of injury consistent with this type of dislocation. As a rule, posterior dislocations frequently are the result of indirect forces producing a combination of internal rotation, adduction, and flexion. This injury can be encountered in the patient with seizures, alcohol withdrawal, or electrical shock. In these patients, the diagnosis should be immediately considered and actively ruled out, even if shoulder pain is not part of the presenting complaint.

Examination. There is a constellation of classic physical findings associated with posterior dislocation that may be found on shoulder examination. Generally, the patient will complain of severe pain; as a rule, these injuries tend to be more painful than anterior dislocations. The patient usually will be sitting with the arm held tightly across the front of the trunk. The arm is fixed in a position of adduction and internal rotation; external rotation, whether active or passive, is blocked and abduction is severely limited. The posterior aspect of the shoulder is rounded and more pronounced than the normal shoulder. In contrast, the anterior aspect of the shoulder is flattened, and the coracoid process is prominent if compared to the uninjured side. These contour changes in the shoulder can best be viewed with the patient sitting on a low stool as the examiner stands behind him or her and the gown is draped beneath the patient's shoulders in the axillae. This permits simultaneous visualization of the front and back of the shoulders (bilaterally) for comparison. A more subtle finding, which is always present, is lack of wrist supination on the affected side when the arms are forward flexed.

Radiographs. Appropriate radiographs should be obtained in order to confirm the diagnosis and to identify associated fractures; nevertheless, the initial diagnosis should be made primarily based on findings generated from physical examination of the patient. A routine anteroposterior (AP) shoulder film usually is sufficient to detect a variety of anterior dislocations. Unfortunately, this radiograph is rarely sufficient to diagnose posterior glenohumeral dislocation. It should be stressed that this type of dislocation may look deceptively normal on the AP radiograph because a "routine" AP film of the shoulder does not afford a true AP view of the glenohumeral joint. *(See Figures 1 [normal] and 2 [dislocation] on insert included with this issue.)* A routine AP view of the shoulder is taken anteroposteriorly to the plane of the chest. The scapula lies on the posterolateral chest wall at an angle of 45° from the frontal plane; the glenoid, therefore, anteriorly faces 45°. As a result, the routine AP radiograph projects a significant overlap shadow of the humeral head superimposed on about three-fourths of the glenoid. This orientation of the glenohumeral joint to the plane of the AP radiograph prevents visualization of the normal joint space; as a result, loss of this joint space, which is not visualized on the standard AP view of the shoulder, is lost in a posterior dislocation, which presents a significant radiographic pitfall.

Another radiographic problem in the evaluation of posterior shoulder dislocation is associated with the lack of perpendicular views. It is essential that injured portions of the skeleton be imaged with two views oriented perpendicular to one another. The "standard" trauma shoulder series in many institutions

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includes AP views in internal and external rotation. Such an approach merely provides two oblique views of the same projection rather than views aligned at 90°; the oblique orientation is not sufficient for diagnosing posterior shoulder dislocations. Either an axillary lateral or scapular lateral view is required for adequate evaluation of the shoulder. The scapular lateral is slightly more difficult to interpret for those not familiar with this projection and, therefore, the axillary lateral is preferred by most physicians.

The point should be made that no AP film made in the plane of the chest is diagnostic of posterior dislocation—these films may only be suggestive of the diagnosis. However, there are specific radiographic signs seen on the routine AP view that point toward this injury.

Absence of the normal elliptical shadow. On the routine AP view, there is usually an overlap shadow created by the head of the humerus superimposed on the glenoid fossa. The shadow is a smooth bordered ellipse. In posterior dislocation, the articular surface of the humeral head is posterior to the glenoid and the elliptical overlap shadow is distorted. *(See Figure 2.)*

Vacant glenoid sign. In the normal shoulder, the humeral head occupies the majority of the glenoid cavity. In posterior dislocations, the head rests behind the glenoid; as a result, the glenoid fossa appears to be partially vacant. This finding has also been referred to as the positive rim sign. If the space between the anterior rim and the humeral head is greater than 6 mm, a posterior dislocation is likely. *(See Figure 2.)*

The "trough line." A "trough line" is noted on the AP radiograph; this is the result of an impaction fracture of the humeral head caused by the posterior rim of the glenoid. It is analogous to the Hill-Sachs impaction fracture seen in anterior dislocations. Radiographically, two parallel lines of cortical bone are visible on the medial cortex of the humeral head. One line represents the medial cortex of the humeral head while the other represents the margin of an impaction fracture. *(See Figure 3.)*

"Hollowed out" or "cystic" humeral head. In posterior dislocation, the arm is locked in internal rotation. The x-ray beam, therefore, passes through both the greater and lesser tuberosities, creating the image of a hollow or cystic humeral head.[1,2,4] *(See Figure 4.)*

The scapular lateral radiograph is, perhaps, the most clinically useful and patient-friendly shoulder film necessary for diagnosis of posterior dislocation; however, it is used infrequently. *(See Figure 5.)* This film can be taken with the patient standing, sitting, or supine, without moving the arm away from the side. It is virtually diagnostic of posterior dislocation. The technique for shooting this film is relatively easy. The arm is left undisturbed in the position of comfort for the patient. The anterolateral portion of the injured shoulder is placed against the cassette. The x-ray beam passes tangentially across the posterolateral chest parallel to and down from the spine of the scapula onto the cassette. The resulting image represents a true lateral of the scapula and, therefore, of the glenohumeral joint. In order to properly interpret the view, one must understand the three-dimensional anatomy of the scapula. In the lateral view, the scapula projects as the letter "Y." The vertical stem of the "Y" is the body of the scapula, and the upper fork is formed by the juncture of the coracoid and the acromion processes. The glenoid is located at the junction of the stem and the apex of the fork, which is visible as a dense circle of bone. In the normal shoulder, the humeral head should be centered on the point of intersection of the stem and branches of the upper fork.

The axillary lateral radiograph is the most commonly ordered lateral view and is also the easiest to interpret. *(See Figure 6.)* Unfortunately, as it is classically described, it requires the patient to lie supine and his or her arm to be abducted 70-90° with the cassette above the shoulder and the tube positioned near the hip. Radiology technicians are understandably reluctant to position the patient in this painful position. There are two commonly used and relatively painless variations of the classic axillary radiograph that also provide an adequate lateral view. A camera axillary lateral view can be obtained without abducting the injured shoulder. In this view, the humerus is forward flexed 20-30°, the cassette is placed superior to the shoulder, and the x-ray tube is inferior to the elbow. The Velpeau axillary lateral projection is another view that does not require abduction of the painful shoulder.[2] In this view, the patient is placed in a Velpeau dressing and asked to lean backward 30° over the cassette on the table. The tube is then positioned above the shoulder and the beam is directed vertically down onto the cassette. This view is particularly helpful following reduction when the patient is in a shoulder immobilizer.

Management. Patients with acute traumatic posterior dislocations are generally in more severe pain than those with anterior dislocations. The use of intravenous sedation and muscle relaxants, while almost always successful in the reduction of anterior dislocations, may be insufficient for posterior dislocations. Not infrequently, these patients require general anesthesia. However, reduction in the ED should be attempted under sedation, with muscle relaxation prior to subjecting the patient to general anesthesia. The patient should be placed supine, and traction should be applied to the adducted arm in the line of deformity. While applying traction, the humeral head should be gently lifted back into the glenoid fossa. The arm should not be forced into external rotation. If the head is locked on the glenoid rim, forced rotation may fracture the head or shaft of the humerus. If the pre-reduction radiographs reveal the head to be locked on the glenoid rim, distal traction should be combined with lateral traction on the upper arm. This combined traction approach can be accomplished by an assistant using a folded towel to apply the lateral contribution.

The type of post-reduction immobilization depends on the stability of the shoulder after reduction. If the shoulder is stable, a sling and swathe or standard immobilizer are adequate. If, however, the shoulder tends to sublux in the sling and swathe, a shoulder spica cast will need to be applied, with the shoulder positioned in external rotation. When available, orthopedic consultation should be obtained in the ED; if it is not available and reduction is correctly performed, prompt outpatient orthopedic follow-up is necessary. Fractures of the glenoid rim, humeral head, tuberosities, and upper humeral shaft are commonly associated with the posterior shoulder dislocation. The incidence of coexistent fractures is approximately 50%.[5] These fractures contribute to the frequency of misdiagnosis as they lead the physician to believe that he or she has identified a source of the pain and motion loss. Posterior dislocation should be considered in all proximal humerus or glenoid fractures; a lateral film must be obtained. Neurologic injuries are far more common with anterior dislocation but still must be ruled out with posterior dislocation. These injuries generally spontaneously recover. Vascular injuries are also rare in glenohumeral dislocations, but must be considered. This is particularly true in the elderly patient who has atherosclerotic vascular disease with loss of vessel elasticity. Oftentimes, the only physical finding in these cases is asymmetry of pulses compared with the normal side.

Inferior (Luxatio Erecta) Glenohumeral Dislocation

Inferior shoulder dislocation, also known as luxatio erecta, is a rare form of shoulder dislocation. The incidence of luxatio erecta is reported to be 0.5% of all shoulder dislocations. Luxatio erecta can occur in any age group. The injury is most often unilateral; simultaneous bilateral luxatio erecta has been reported.

Luxatio erecta presents in a unique and unusual fashion. The initial impression may suggest hysteria. Careful attention must be directed toward making the distinction between anterior and inferior shoulder dislocations. A recent report describing luxatio erecta suggests it is initially misdiagnosed as an anterior dislocation.[6] In this case, standard approaches to reduction of anterior dislocation were unsuccessful. Only after orthopedic referral and complete radiographic evaluation was the correct diagnosis made. Multiple attempts at reduction carry the risks of iatrogenic injury. Consequently, the suspicion of luxatio erecta must be present when examining all shoulder dislocations.

The mechanism of injury involves hyperabduction of the arm at the shoulder with extension at the elbow. The forearm is pronated. Direct or violent force is applied to the shoulder from a superior direction, causing inferior movement of the humeral head relative to the glenoid fossa. The inferior portion of the glenohumeral capsule is then disrupted, and inferior glenohumeral dislocation occurs. Alternatively, leverage of the humeral head across the acromion by a hyperabduction force also can result in inferior dislocation of the humeral head.

Clinical Presentation. The presentation of inferior dislocation of the shoulder is unique. The patient usually presents in distress with the involved arm hyperabducted at the shoulder and flexed at the elbow. The forearm frequently rests behind the head. An anxious patient presenting with either one or both arms raised above the head can suggest hysteria. Patient or physician attempts at adduction are extremely painful. The glenoid fossa is empty and the humeral head is palpitated in the axilla adjacent to the lateral chest wall. Skin creases are noted on the superior aspect of the shoulder, indicating the acute angle formed by the acromion and humerus. Neurovascular compromise may be found. Radiographic examination of the shoulder in cases of suspected luxatio erecta includes the following views: AP views in both internal and external rotation and lateral views including the "Y" or axillary approaches. The AP view often will demonstrate an inferior displacement of the humeral head relative to the glenoid; furthermore, the arm is hyerabducted at the shoulder. *(See Figure 7A.)* The lateral views, in particular the axillary view, closely defines the relationship of the humeral head and glenoid fossa and are of significant use in difficult cases.

Treatment in the ED most frequently involves closed reduction with adequate muscle relaxation and anesthesia. *(See Figure 7B.)* In-line traction should be applied to the fully abducted arm while firm, cephalad pressure is maintained on the humeral head. Counter-traction is used with a rolled bed sheet placed superior to the shoulder.[7] When the humeral head is reduced into the glenoid fossa, the arm is adducted toward the body and the forearm is supinate. Post reduction, the shoulder is immobilized in the typical fashion (either a sling and swathe or shoulder immobilization), and outpatient orthopedic referral should be arranged.

Associated injuries are common and include: disruptions of various shoulder muscles (supraspinatus, infraspinatus, subscapularis, and pectoralis major); fractures of the clavicle, coracoid, acromion, inferior glenoid, and greater tuberosity of the humerus; and neurovascular compromise involving the brachial plexus and the axillary artery. Concomitant fracture or rotator cuff injury is reported in 80% of cases. Additionally, 60% of these patients manifest neurologic injury on presentation, most commonly to the axillary nerve. The neurologic deficits usually resolve in rapid fashion. A small percentage of cases are complicated by vascular injury. Fracture of the greater tuberosity of the humerus reportedly spares injury to the rotator cuff. The prognosis for normal shoulder function in complicated cases is usually favorable. Recurrent inferior dislocation of the shoulder is very unusual. Violent injuries have resulted in open fractures complicating the inferior dislocation.

Elbow Fractures

Injuries involving the elbow usually are correctly diagnosed and appropriately managed in the ED. Two specific injuries, however, are frequently missed: the pediatric supracondylar fracture and the adult radial head fracture. Both injuries present with significant pain and nonspecific soft-tissue swelling and tenderness. The radiograph may be unrevealing, since, in children, the elbow is a difficult area to evaluate roentgenographically with the multiple ossification centers, and the adult elbow often "hides" fracture.

Supracondylar Fracture. The supracondylar fracture is a bony injury of the distal humerus that is found proximal to the epicondyles. The vast majority of patients with supracondylar fracture are children, with a mean age of 7 years; this type of fracture is rare after the patient reaches 15 years of age. This pediatric prevalence results from a mismatch in structural strength among the various elbow tissues. The ligamentous and capsular tissues are relatively stronger than the bony structures. Consequently, stress in this region is more likely to produce bony injury rather than soft-tissue disruption; the converse is true with the adult, in that a similar injury mechanism results in posterior elbow dislocation. Supracondylar fractures are described as either flexion or extension type; flexion fractures account for a small percentage of supracondylar injuries, while extension-mediated lesions occur in more than 95% of cases.

As a rule, extension supracondylar fractures result from a fall on the outstretched arm with the elbow fully extended or hyperextended. The force of impact is usually directed in forward fashion, producing a torque force at the elbow. The distal humerus in the supracondylar region then fractures in the anterior aspect. Contraction of the triceps muscle frequently pulls the distal fragment both posteriorly and proximally. In the rare case, the sharp end of the fracture fragment may enter the antecubital area, producing neurovascular injury to the brachial artery and median nerve; most often, soft-tissue protects the neurovascular structures from laceration.

Clinical Presentation. Examination will reveal a child in significant distress, holding the arm extended at the elbow in the usual "S"-shaped position. Soft-tissue swelling and tenderness are found about the elbow, and limited range of motion is noted on examination. With complete fractures, the olecranon, which is attached to the fracture fragment, is palpable. Incomplete fractures produce less obvious deformity; soft-tissue swelling and nonspecific tenderness may be the only findings. The neurovascular status must be evaluated.

Radiographically, complete injuries are obvious on the film. On the lateral view, the fractured fragment is displaced proximally and posteriorly; the AP film may reveal medial or lateral displacement of the fragment. Since these fractures predominantly occur in children with elastic bony structures, incomplete injuries are common and represent a diagnostic challenge. In fact, approximately one-quarter of supracondylar fractures are of the greenstick variety—disruption occurs along the anterior aspect of the humerus while the posterior portion remains intact. The lateral view may demonstrate only abnormal fat pads while the AP film may be negative, particularly if the fracture line is transversely oriented. Fractures may be divided as follows: Type I, minimal to no displacement; Type II, incomplete injury with minimal to moderate displacement and/or intact posterior cortex; and Type III, complete displacement of fragment with posterior cortical disruption. In most instances, the fracture is apparent on the film; certain patients, however, will have occult bony injury. Two radiographic markers are useful in this setting—the anterior humeral line *(see Figures 8 and 9)* and the fat pad signs. *(See Figure 10.)* The anterior humeral line is helpful in evaluating possible supracondylar fracture in the pediatric patient. A line is drawn along the anterior aspect of the distal humerus extending through the elbow. In the normal state, the line will bisect the middle of the capitellum. *(See Figure 8.)* In the child with a supracondylar fracture, this line will either strike the anterior third of the capitellum or miss it entirely, appearing anterior to the capitellum. *(See Figure 9.)*

The fat pad sign results from swelling adjacent to the distal humerus. In the uninjured elbow, fat located about the elbow joint found in bony recesses and is essentially radiographically hidden. The anterior fat pad is often present in the normal patient as a narrow strip of radiolucency along the distal humerus; the posterior fat pad is not seen in the uninjured patient. With fractures involving intra-articular structures about the elbow, hemorrhage and/or edema fluid will distend the joint capsule and displace the fat out of the bony concavities, producing the radiographically evident fat pad signs. The abnormal anterior fat pad is seen as a triangular structure resembling a sail boat spinnaker along the anterior aspect of the distal humerus. The appearance of a posterior fat pad of any morphology is considered abnormal. In the patient with traumatic elbow pain, an abnormal fat pad is associated with fracture in 90% of cases. The presence of a fat pad should prompt the emergency physician to strongly consider an occult fracture, especially an incomplete supracondylar fracture in a child or a radial head fracture in the adult.

Management. Treatment in the ED should be tailored according to radiographic injury type listed above. Type I fractures are mechanically stable; splinting may be used primarily for pain control and comfort. Type II injuries should be reduced, preferably by an orthopedist. After reduction, splinting or casting at 120° of flexion is recommended in most cases; the exception is the patient with significant soft-tissue swelling who is at risk for vascular compromise at the elbow. A rare patient with Type II injury may require surgical stabilization.

Type III fractures require ED reduction, once again, by an orthopedist. These fractures are associated with loss of arm length, various deformities, and neurovascular compromise. The emergency physician may attempt reduction if vascular compromise is encountered; otherwise, this maneuver should be performed by an orthopedic surgeon in the ED at the time of initial visit. Closed reduction can be accomplished after adequate conscious sedation (muscle relaxation/pain control) has been achieved. The physician applies traction at the wrist in line with the upper extremity, with the thumb in the "up" position. Any medial or lateral deformity is corrected. With restoration of the arm's length, the elbow is slowly and gently flexed to 100°. Any angulation is corrected at this stage. Supracondylar fractures with medial displacement are immobilized with the forearm pronated; laterally displaced fractures are immobilized with the arm supinate. Post-reduction radiographs should be obtained while a repeat neurovascular examination is performed. If this reduction attempt is unsuccessful, further attempts should not be made. Circulation may be restored with traction applied to the arm with the elbow extended while the orthopedist is en route to the ED. Admission to the hospital should be considered with a displaced supracondylar fracture since these patients are prone to vascular compromise. Inpatient disposition allows close observation of the perfusion status of the arm. In most cases of compromised perfusion, edema rather than arterial injury is the usual culprit force.

Radial Head Fracture

The radial head fracture usually results from a fall on the outstretched hand in an adult patient. The impact is transmitted axially through the radius, forcing the radial head against the capitellum; the proximal radius is a relatively weaker structure compared to the capitellum, resulting in a fracture. The examination is nonspecific, revealing tenderness and soft-tissue swelling at the elbow. The radiograph may demonstrate either an obvious fracture or only the presence of pathologic fat pads, which are strongly suggestive of an occult fracture. Undisplaced radial head fractures are difficult to detect radiographically. The normal cortex of the radial head is smooth with a continuous concave morphology. Consequently, any irregularity of the radial head, particularly in association with an abnormal fat pad, is a radial head fracture until proven otherwise. *(See Figure 11.)* As with the supracondylar fracture, the radial head fracture may be classified along the following lines: Type I, undisplaced; Type II, minimal displacement; Type III, comminuted fracture; and Type IV, any fracture with dislocation.

Type I injuries are symptomatically treated with sling support and early application of range-of-motion exercises (initiated on day two). Joint aspiration with infusion of an anesthetic agent may drastically reduce pain, although this maneuver has no effect on outcome. Most patients will return to preinjury functional status, although a minority of patients will experience long-term disability (pain and contracture). Type II injuries may be treated in similar fashion; such patients may require surgery with excision of the radial head if patients fail range-of-motion maneuvering. Type III injuries should receive a similar approach in the ED with early orthopedic follow-up for surgical removal of the radial head. Type IV fractures are managed with reduction of dislocation and early surgical excision of the radial head. Outcomes of patients with Types III and IV fractures are excellent.

Wrist Injuries

One of the most common but inaccurate diagnoses made in the injured extremity is wrist sprain. Although wrist sprains do occur, the diagnosis should only be considered *after* careful physical and radiographic examinations have ruled out fracture and dislocation in this anatomic region. In fact, the diagnosis of *wrist* sprain usually is one of *exclusion*. Accurate diagnosis of wrist injuries is dependent on a thorough knowledge of the topographical anatomy of the wrist and careful, systematic evaluation of the extremity and appropriate radiographs. Although the wrist fracture/dislocation is a rare entity among all cases of extremity trauma, several injuries deserve attention, including scaphoid fractures, scapholunate dissociations, distal radioulnar joint dislocations, hamate hook fractures, and triquetral avulsion fractures. These injuries are easily missed in the ED and have significant morbidity associated with delayed diagnosis.

Since demonstration of specific point tenderness within the carpus is the most important diagnostic test in assessing injuries to the wrist, it is critical that physicians be comfortable with the anatomy of this area. The wrist bones should be palpable in the normal uninjured wrist. Radially, the anatomic snuffbox is the area between the tendons of the first and third dorsal compartments on the radial side of the wrist. This area is best palpated by bringing the thumb into radial abduction (the hitchhiker's position), defining the hollow situated between the extensor pollicus longus, the abductor pollicus longus, and extensor pollicus brevis. The radial styloid is palpable at the base of the snuffbox, and the body of the scaphoid is palpable in the depths of this area. On the ulnar aspect of the wrist, the ulnar head and styloid are palpated. The position of these structures varies with pronation and supination of the forearm. In a neutral position, the ulnar styloid is prominent at the ulnar side of the wrist. The ulnar head is palpable dorsally in pronation and palmarly in supination.

On the palmar aspect, the distal wrist crease is the visible landmark that defines the underlying anatomy. Radially, at the intersection of the flexor carpi radialis tendon and the wrist crease, the scaphoid tuberosity is palpable as a bony prominence at the base of the thenar muscles. Ulnarly, the pisiform is palpable at the junction of the flexor carpi ulnaris and the wrist crease. Immediately distal and radial to the pisiform is the hook of the hamate. The area between the scaphoid tuberosity and the pisiform contains the contents of the carpal tunnel, the area where abnormal prominences will be palpable in perilunate dislocations. The area just proximal to the proximal wrist crease is where the ulnar head will be palpably prominent in a volar dislocation of the distal radioulnar joint.

On the dorsum of the wrist, Lister's tubercle is the most significant landmark. Just distal to this bony ridge is the scapholunate junction. Just distal to the ulnar head and radial to its styloid lies the lunotriquetral junction. These two areas are common sites of injury. Dorsally, abnormal bony prominences usually represent the dorsally displaced rim of the distal radius or the proximal row of carpal bones that are palpable because of the dorsal collapse of the fractured distal radius. The distal ulna will also seem prominent relative to a shortened distal radius. The metacarpal shafts are easily palpable on the dorsum of the hand, and, when followed proximally, they lead to the easily palpable prominences of the carpometacarpal joints, which are the most distal structures of the wrist.

Familiarity with this anatomy is critical since the best and most dependable sign of carpal injury is specific and well-localized point tenderness. Fractures of the scaphoid demonstrate point tenderness in the anatomic snuffbox and over the scaphoid tuberosity. Scapholunate and lunate injuries will be maximally tender just distal to Lister's tubercle on the dorsum of the wrist. Triquetral and lunotriquetral injuries will be tender over the dorsum of the appropriate bone one fingerbreadth distal to the ulnar head. The diagnosis of a hamate hook fracture is almost always made clinically by eliciting tenderness over the area just distal and radial to the pisiform.

Scaphoid Fracture. Of all wrist injuries, fracture of the scaphoid is the most commonly missed diagnosis. Fractures of the scaphoid account for 60-70% of all diagnosed carpal injuries. Radiographic findings are either subtle or absent, making the diagnosis difficult in the absence of a thorough clinical examination by an informed clinician who has a high index of suspicion. Accurate, early diagnosis is critical, as the morbidity associated with a missed or late diagnosis is significant.

The classic history for scaphoid fracture is a fall on the outstretched hand (FOOSH). The patient generally has immediate pain, but may have little or no swelling and is able to continue his or her activity. Not uncommonly, these injuries are associated with other injuries about the upper extremity; the wrist complaint may actually be a lower priority from the patient's perspective. Proper palpation during physical examination, however, will exacerbate pain, prompting the physician to obtain the proper films. The patient's degree of swelling, discomfort, and motion loss are variable. Palpation of the scaphoid body in the anatomic snuffbox is the most reliable diagnostic maneuver. Additionally, however, direct palpation of the scaphoid tuberosity palmarly should also elicit complaints of tenderness.

*Radiography***.** Although the diagnosis of scaphoid fracture is suggested by the history and physical examination, in a majority of cases it is confirmed only by radiographic evaluation. It is critical to visualize the bone with two views oriented perpendicularly. On the AP view, it is best to align the longitudinal axis of the scaphoid parallel with the film; this alignment is best accomplished by positioning the wrist in ulnar deviation, placing the scaphoid in an extended position. Performing this view with the fist clenched will also provide an axial load and accentuate any scapholunate diastasis that may be present as part of a scapholunate dissociation. Even with appropriate films, these fractures can be subtle and difficult to see. A significant percentage of these fractures will not be acutely visible on any view. *(See Figures 12 and 13.)* In the acute management of these injuries, the films are actually more important for ruling out concomitant injuries than for accurately diagnosing the scaphoid fracture itself.

All suspected scaphoid fractures initially should be treated as though a fracture exists (i.e., splint and refer to an orthopedist for repeat evaluation). Since a number of these fractures are not radiographically detectable on initial presentation, any patient with an appropriate history and snuffbox or tuberosity tenderness should be treated with a thumb spica splint and evaluated by an orthopedist in 10-14 days for repeat studies. Strict adherence to this policy will ensure that any fracture with subtle or absent radiographic initial findings will still be appropriately treated without delay. An undiagnosed and improperly treated scaphoid fracture is complicated by chronic pain, reduced functional ability, and early arthritis due to the ischemic necrosis and malunion. *(See Figure 13.)*

Scapholunate Dissociation

Scapholunate dissociation is the most common form of carpal instability. Despite the literature supporting the importance of early diagnosis and treatment, this problem is rarely recognized on initial presentation. With the growing awareness of the problem of occult scaphoid fracture, scapholunate dissociation seems to have replaced this carpal fracture as the most commonly misdiagnosed cause of the wrist sprain diagnosis. If recognized initially and treated appropriately, this condition has a very good prognosis for recovery of both motion and function. If treatment is delayed, however, chronic disability is inevitable. These patients do not necessarily have tenderness in the anatomic snuffbox and their symptoms resolve rapidly; consequently, if the diagnosis is not made or suspected in the ED, the patient may never see an orthopedist until the condition becomes chronic and the outcome much less favorable.

These injuries occur with hyperextension and/or the FOOSH mechanism. Subjectively, the complaints of pain vary from minimal to excruciating. Patients will often complain of weakness and possibly a “click” or “clunk” with gripping activity. Additionally, the patient who presents to the ED with complaints of a growing dorsal wrist mass should be evaluated with radiographs as a dorsal ganglion can be associated with the chronic form of this condition. The most important aspect of the physical examination, as with all wrist injuries, is precise localization of the point of maximal tenderness. These patients will localize their tenderness to the scapholunate junction, which is palpable just distal to Lister’s tubercle. They may or may not also have snuffbox or tuberosity tenderness. Wrist motion is variable and may be extremely limited or may be nearly normal; the degree of swelling is also very variable.

Radiographs. The radiographic findings in this condition are numerous and readily visible on three films. The supinate AP, clenched fist AP, and lateral views will demonstrate the following characteristic findings: 1.) widening of the scapholunate gap greater 3 mm, the Terry Thomas sign (an indicator of scapholunate dissociation that is best visualized on a is supinate AP or clenched fist AP view) *(See Figure 14.)*; 2.) foreshortened appearance of the scaphoid in palmar flexed position on the AP view; 3.) cortical ring sign seen in the AP view, representing a double density shadow produced by the axial projection of the abnormally oriented scaphoid upon itself; 4.) on the lateral view, the scaphoid lies more perpendicular to the axis of the radius rather than at its usual angle of 45-60°; 5.) trapezoidal lunate as seen on the AP view is produced by a triangular shape of the lunate as it overlaps the capitate, an indicator of the rotation of the lunate into an extended position; and 6.) Taleisnik’s “V” sign is produced by palmar flexion of the scaphoid leading to a more acute angle between the distal radius and scaphoid forming a sharper “V” shaped pattern rather than the broad, c-shaped arc seen in the normal wrist.

Treatment for this disorder is relatively simple in the ED. A thumb spica splint is applied acutely and referral is made to an orthopedic or hand surgeon for operative repair. This referral is not emergent, although the patient should be seen within 10 days to facilitate early repair. The real key for ensuring appropriate treatment for this potentially disabling condition is to have a high index of suspicion and to make the diagnosis acutely so that early repair is possible.

Dislocations of the Distal Radioulnar Joint

Isolated dislocation of the distal radioulnar joint is uncommon; unfortunately, however, it may not be initially recognized in the ED. Delay in the treatment of this injury leads to significant disability, since treatment options for chronic distal radioulnar joint are limited and suboptimal. However, this injury is relatively easy to treat and carries a reasonable prognosis if recognized early.

Isolated subluxations or dislocations of this joint occur from falls, twisting injuries, or suddenly lifting heavy loads with the wrist outstretched. Although the ulna actually stays fixed in space, it is actually the radius and carpus that dislocate about the ulna; convention dictates that these injuries be classified according to the position of the ulna relative to the radius. Dorsal dislocations of the ulna occur with hyperpronation injuries, while palmar or volar dislocations occur with hypersupination injuries. Patients complain of a painful loss of rotation of the forearm. The clinical examination, therefore, is critical for diagnosing the condition. Dorsal dislocations present with an asymmetrically prominent distal ulna dorsally associated with a painful loss of supination. Palmar dislocation manifests with a wrist that is narrowed in its AP diameter and full on the palmar ulnar aspect; a corresponding dorsal sulcus (i.e., an empty space) where the ulnar head should be palpable. Pronation is painfully limited or impossible.

Radiographs. Subluxations and dislocations of the distal radioulnar joint can be difficult to detect radiographically. The signs are often subtle and only are apparent if there is a high index of suspicion. Inability of the technician to obtain what you believe to be adequate AP and lateral films should trigger suspicion of this injury. It is very difficult to obtain true laterals in this condition. Dorsal dislocations, in particular, are difficult to recognize. The appearance of the ulnar head dorsally above the radius can be misleading. When the head of the ulna appears dorsally, the clinician should evaluate the alignment of the triquetrum with the ulna on the lateral view; if the triquetrum is not aligned with the ulna, a dorsal dislocation is likely. Palmar dislocation is somewhat easier to recognize. On the AP view, the ulnar head lies partially superimposed on the radial metaphysis, the forearm is narrowed, the sigmoid notch is empty, and the ulnar styloid is often fractured near its base. *(See Figure 15.)* On the lateral view, the ulna is displaced beneath the radial metaphysis. *(See Figure 16.)*

Management. Acute dorsal subluxation should be managed by reducing the ulnar head and immobilizing the forearm in full supination with a sugartong splint or volar and dorsal splints that cross the elbow. Palmar dislocation is often locked and usually cannot be reduced without regional anesthesia, although an attempt can be made using conscious sedation. Direct pressure on the ulnar head with counter-pressure over the distal radius may allow reduction. Hypersupination may be necessary to unlock the ulnar head. Once reduced, the forearm should be immobilized in pronation. The volar dislocation is generally stable after reduction. Prompt referral to an orthopedic or hand surgeon is indicated for definitive care.

Fractures of the Hook of the Hamate. Fractures of the hook of the hamate are uncommon injuries that are commonly missed. If detected early and immobilized, they have a reasonable chance of healing without sequelae. Usually, however, the diagnosis is delayed and these fractures progress to nonunion. Treatment for nonunion is surgical excision of the fragment. This fracture may occur from a fall on the dorsiflexed wrist with tension exerted through the transverse metacarpal ligament and the pisohamate ligament. More commonly, however, this fracture occurs when patients are involved in sports that require use of clubs, bats, or racquets; these objects fracture the hamate through direct forces applied to the hypothenar eminence. The history and mechanism provide clues that raise the index of suspicion for these fractures. Patients will complain of weak and painful grip and report discomfort with direct pressure over the hypothenar eminence.

These patients will generally have a full range of motion and minimal, if any, swelling. They will have a weak grip compared with the opposite side. The definitive physical finding is identifying the point of maximal tenderness to deep palpation. Usually, the point of maximal tenderness will be just distal, radial, and deep to the pisiform. When a hamate hook fracture is suspected, standard AP and lateral views should be obtained to rule out other injuries. These views, however, will not assist in the diagnosis of the hamate hook fracture. A carpal tunnel view is the best plain radiograph for identifying this injury. Even this view, however, may not demonstrate the fracture and, if clinical suspicion is high, a CT scan is the definitive study.

Treatment for this injury is a short arm cast for 4-6 weeks. In the ED, a short-armed volar splint, which leaves the metacarpal phalangeal joints free to flex, is appropriate. Referral to an orthopedist is indicated for definitive treatment.

Dislocations of the Carpometacarpal Joints. The carpometacarpal (CMC) joints of the hand, excluding the thumb, are extremely stable joints with relatively limited motion. They have significant bony and ligamentous supports that fix them in position. As a result, isolated dislocations are not common. Dislocations are usually associated with significant trauma and frequently are associated with fractures of the base of the metacarpal. Isolated dislocations do occur, however, and the fourth and fifth CMC joints are the most common sites, since they have the greatest degree of motion and related laxity. Numerous attempts in the laboratory have failed to produce a precise reproducible mechanism for isolated dislocations to these joints. Usually, however, they result from extreme violence, such as motor vehicle accidents or direct blows from heavy, falling objects. Alternatively, on occasion, they are associated with direct blows with a closed fist against an immovable object such as a brick wall. These dislocations are high-energy injuries and should alert the physician to search for other associated injuries to the hand and wrist. They are commonly associated with fractures of adjacent metacarpals.

The gross deformity of the subluxed or dislocated joint is often obscured by the severe swelling present on the dorsum of the hand. An obvious step-off deformity may be observed and/or palpated at the level of the dislocation (i.e., note the proximal end of the metacarpal as it overrides the distal carpus. *(See Figure 17.)* The points of maximum tenderness will be over the metacarpal bases and any areas of corresponding fractures. There may be rotational deformity of the digits or shortening of the metacarpal with attempted fisting. In all these injuries, a careful assessment should be made of the neurovascular status of the hand. In dislocations of the fifth CMC joint (the most common injury pattern), specific attention should be directed to the status of the deep branch of the ulnar nerve in that it lies immediately volar to the fifth CMC joint where it winds around the hook of the hamate. The median nerve may also be injured, particularly with dislocation patterns resulting from a direct blow to the hand. Vascular compromise, particularly in patients with injury to the third metacarpal, may involve the deep palmar arterial arch that lies directly beneath the third CMC joint. Integrity of the wrist extensor tendons must also be assessed in these dislocation injuries, since disruption of these structures may occur. Additionally, those patients who have suffered a direct blow are at risk for compartment syndrome in the hand.

Radiographs. The radiographic series for assessing these injuries should include an AP, lateral, and oblique view of the wrist. The AP view may reveal an overlap of the carpal bones over the proximal metacarpals. *(See Figure 18.)* The lateral radiograph often is diagnostic, demonstrating obvious dislocation of the CMC joint. *(See Figure 19.)* The oblique films should be taken with the hand pronated and is supinate, respectively, from the true lateral perspective. The critical factor for the physician reviewing the films is to recognize the potential for this injury any time there is a displaced fracture of a metacarpal. The metacarpals are tightly tethered together, and these injuries can be analogous to Galleazi and Monteggia fractures in the forearm. Any displaced metacarpal fracture should, therefore, elicit concern about injury to the adjacent CMC joints.

Acute treatment in the ED consists of ruling out compartment syndrome and attempting closed reduction. This can usually be accomplished with longitudinal traction, which is most easily accomplished by hanging the patient in finger traps with 5-10 lbs of weight suspended from the arm. The hand should then be splinted, with digital motion encouraged to prevent stiffness associated with swelling. The patient must be referred for definitive care, since these injuries often require percutaneous pinning or open reduction/internal fixation.

Closed Tendon Injuries of the Hand. In Rockwood and Green’s textbook on fractures, it is stated that “ . . . the initial evaluation and care of the injured hand are critical, for at that time the surgeon has his best opportunity to assess accurately the extent of damage and to restore the altered anatomy.” They further state that “ . . . many authors have observed that the fate of the hand largely depends on the judgment of the doctor who first sees the patient.” The surgeon is rarely the one who first sees the patient, and the ultimate outcome in these injuries often depends on the appropriateness of the diagnosis and treatment provided in the ED.

Closed tendon injuries of the hand frequently are not treated with the same respect as other injuries. When there are no open wounds and no fractures present on x-ray, these injuries are often viewed as minor. In fact, these injuries can result in debilitating deformities if left untreated. As with many hand injuries, treatment is relatively simple and successful if instituted early. If the diagnosis is initially missed, however, the resultant deformities may require surgical reconstruction or joint arthrodesis. These injuries occur at all three joints of the digits and on both the flexor and extensor aspects of the hand.

Flexor Digitorum Profundus Rupture. Injuries to the flexor digitorum profundus tendon of the digits are often called "rugger jersey" injuries, a relatively uncommon mishap that is often missed on initial evaluation. A high index of suspicion is necessary, for in most cases early surgical repair will provide a good result. Avulsion of the profundus tendon is caused by forceful hyperextension of the distal interphalangeal (IP) joint while the profundus tendon is maximally contracted. It is most commonly seen in athletic events when a player grabs at an opposing player's jersey. The ring finger is most commonly involved but all fingers are susceptible. The tendon may pull directly off the distal phalanx or it may avulse a bone fragment of variable size. Because the tissue is torn and not lacerated, the degree of soft tissue injury and hemorrhage is greater than that seen with a laceration in the same zone. As a result, the scarring within the sheath is often significant and the adjacent superficialis tendon may become secondarily involved. Additionally, the avulsed fragment may catch at the level of the superficialis chiasm and a flexion contracture may develop at the proximal IP joint. These injuries often go unnoticed or ignored by the patient and he or she may come to the ED late because of persistent pain and swelling of the proximal IP joint. Patients may also complain of the inability to make a complete fist.

Since the radiographs are often normal in this condition, the diagnosis must be made on physical examination. The deformity is a subtle one with only a slight loss of the normal flexion cascade of the fingers. On clinical examination, the patient will have inability to actively flex the distal IP joint when the proximal IP joint is blocked in extension *(see Figure 20.)*; loss of the normal flexion cascade is seen with the involved digit remaining in either partial or complete extension in comparison to the other fully flexed digits. *(See Figure 20.)* A tender fullness at the proximal IP joint or proximal digital crease where the tendon has retracted is often demonstrated. AP and lateral views of the digit (not the hand) should be obtained to evaluate the injury for bony involvement. Fracture may have an effect on both the timing and type of surgical repair. Most of these injuries, however, will have normal films.

Definitive treatment of these injuries must be individualized according to the needs and desires of the patient. From an ED standpoint, however, all of these patients should be considered surgical candidates. In order to ensure that repair is a viable option, all patients should be placed in a dorsal splint and referred to a surgeon within 7-10 days of injury. The position of splinting is at 30° of wrist flexion, 70° of metacarpalphalangeal joint flexion, and 30-45° of IP flexion.

Mallet Finger. Mallet finger is produced by a closed injury resulting in disruption of the distal extensor apparatus of the digit. A flexion deformity at the distal IP joint is noted. This injury generally results from a direct blow that forcibly flexes an extended finger. It can, however, occur with relatively minor trauma to the fingertip or even a direct blow to the dorsum of the finger. Additionally, the extensor lag at the distal IP joint may not appear for several days. This is rarely a painful condition, which is why patients frequently seek help late in the course. Patients will rarely complain of functional disability since there are relatively few activities that require full digital extension. This injury is one that patients commonly choose to ignore when faced with a prolonged treatment plan. What they fail to realize, however, is that, if left untreated, the chronic mallet finger may go on to develop a swan neck deformity of the digit. Unfortunately, many patients are also led to believe at their ED encounter that this is a simple problem to treat and that these injuries universally do well. Unfortunately, that is not the case and it is always best if the patient hears the correct information from the first physician whom they encounter.

Acutely, patients may have ecchymosis over the dorsum of the distal IP joint but there may be no tenderness, swelling, or discoloration. *(See Figure 21.)* All patients will exhibit an extensor lag at the distal IP joint, with the magnitude of the lag varying depending on the type and severity of injury. *(See Figure 21.)* Be aware that, on rare occasions, a locked trigger finger has been misdiagnosed as a mallet finger; mallet fingers are passively correctable to full extension, without catching or triggering.

Soft-tissue mallet fingers should be immobilized in extension full time for eight weeks. *(See Figure 22.)* The patient must understand that if he or she takes the finger out of immobilization to wash or air it out that he or she cannot let the distal IP joint fall into flexion. Each time the distal IP joint flexes, the treatment clock starts over again at time zero. Skin breakdown can be a significant problem, and patients should be instructed to remove the splint daily while holding the joint in extension, resting the joint on a flat surface to allow the skin to dry and reduce the chance of maceration. The vast majority of hand surgeons would recommend immobilizing only the affected joint. Routine referral to an orthopedist for definitive care is indicated.

Acute Rupture of the Central Slip (Extensor Mechanism). Injuries to the proximal IP joint are extremely common; associated proximal extensor apparatus disruption also is frequently noted. Dislocations of this joint occur frequently in athletes and are often reduced on the field by coaches, trainers, or the players themselves. This "field" correction prevents the treating physician from observing the position of the dislocation. The injured structures should be assessed by physical examination.[8] Failure to recognize a central slip rupture acutely can result in a boutonniere deformity. This is one of the most difficult, least gratifying hand deformities to treat. Early recognition and treatment in the ED is critical to prevent this late and problematic deformity.

Acute central slip ruptures occur by one of two mechanisms, the most common of which is forced flexion of the proximal IP joint that is held rigidly in extension. This mechanism is seen in basketball players and martial artists who use open hand-blocking techniques. Volar dislocations of the proximal IP joint are also a cause of central slip rupture; these are rare injuries that are accompanied by central slip disruption. An unreduced volar dislocation will present with the obvious deformity of the proximal IP joint. The middle phalanx will be palmar to the proximal phalanx. Some patients present with an acute boutonniere (buttonhole) deformity with flexion of the proximal IP joint and hyperextension of the distal IP and metacarpophalangeal joints.[8] In these patients, the proximal IP joint can be passively brought to full extension, but active extension is not possible. The patient who presents, however, with a painful, swollen proximal IP joint *without* gross deformity is the one who requires careful examination. Once again, it is the area of maximum tenderness that will lead the physician to the proper diagnosis. The patient will usually have tenderness near one or both of the collateral ligaments and only mild to minimal tenderness over the volar plate. The area of maximum tenderness will be over the central slip on the dorsal aspect of the proximal IP joint. Generally, this area will also be ecchymotic. Acutely, the patient may or may not be able to fully extend the proximal IP joint. Do not be reassured by full, active extension, since this movement does not assure the integrity of the central slip. In the acute setting, the patient may be able to fully extend through the action of the lateral bands despite a complete rupture of the central slip.

Radiographs. AP and lateral radiographs of the digit should be obtained when this injury is suspected. In a volar dislocation, the base of the proximal phalanx is volar relative to the head of the middle phalanx. If the dislocation has been reduced, or if the rupture is isolated without dislocation, the radiographs will be normal.

Physical examination will help make the diagnosis of central slip injury but may not clarify whether the structure is partially or completely torn, since active extension may still be present. The prudent course, therefore, is to initially treat all central slip injuries as though they are complete ruptures. The proximal IP joint should be splinted in extension, leaving the distal proximal IP and metacarpophalangeal joints free to move. The patient should be instructed to aggressively move the distal IP joint so as not to develop an extension contracture. Referral should be made to an orthopedist or hand surgeon at 10-14 days to re-evaluate the degree of the injury. Definitive treatment will consist of 3-4 weeks of static extension splinting, followed by 2-3 weeks of dynamic extension splinting.

Traumatic Rupture of the Extensor Hood. Subluxation or dislocation of the extensor hood may occur at the metacarpophalangeal joint secondary to acute rupture of the extensor mechanism. This injury occurs following a forceful flexion or extension injury of the digit and is often called the “flea flicker” injury because it occurs when the finger is used to forcefully flick something away. The patient presents with a history of forced flexion or extension at the metacarpophalangeal joint with immediate pain and loss of extension. Patients will complain of a persistent loss of extension or of painful popping over the dorsum of the joint with attempts at motion. The middle finger is most commonly involved, followed by the index finger.

Examination reveals loss of active extension of the metacarpophalangeal joint. When the joint is passively brought into extension, the tendon can be seen to centrally relocate over the joint, and the patient will then be able to maintain extension actively. The tendon is usually subluxed ulnarly due to tearing of the sagittal fibers on the radial side. Passive range of motion at the joint should be normal, although the patient may report pain as the metacarpophalangeal joint is brought into extension with tendon relocation. AP, lateral, and oblique radiographs should be obtained.

These injuries are usually treated with acute surgical repair; however, some authors advocate nonoperative management with extension splinting. Splinting of the metacarpophalangeal joint in full extension is not recommended because of the potential for developing an extension contracture. In this case, the metacarpophalangeal joint should be passively brought into extension just until the tendon is seen to relocate. The joint should then be splinted in that position. The other MP joints should be left free, however, to ensure that no contractures develop in adjacent digits.

Ulnar Collateral Ligament Rupture. Rupture of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb is a common athletic injury. Patients are often anxious to return to their normal activity level and will actively seek such reassurance. Therefore, it is critical that the clinician understand that *all* injuries to this ligament warrant referral to an orthopedic surgeon. Even incomplete lesions require casting or customized bracing due to the high potential for long-term morbidity.

A sudden valgus stress, usually associated with hyperextension, applied to the thumb results in partial or complete tearing of the ulnar collateral ligament that is frequently associated with injury to the volar plate. Ulnar collateral ligament injury often occurs with ski poles, resulting in the term “skier’s thumb.”[9] It is also very common among basketball players and in the “grappling” sports such as wrestling or the martial arts. Patients will often give the history that they saw the thumb “pointing away” from the hand and will note pain, swelling, and weakness of pinch/grip.

The thumb will be swollen, painful with motion, and may have a gross deviation radially. The point of maximal tenderness is elicited over the ulnar aspect of the metacarpophalangeal joint. Differentiating complete from incomplete ruptures requires stressing of the joint, but this should never be done prior to x-ray.[10] If the ligament has avulsed a piece of bone off the proximal phalanx, stress testing could displace the fragment. AP and lateral radiographs should be obtained. The AP is assessed for bony injury at the phalangeal or metacarpal attachment of the ligament. A displaced or rotated fragment off the phalanx is a definite indication for surgery. The lateral film is often overlooked or ignored. Any evidence on this film of volar subluxation of the phalanx is an indicator of significant ligamentous injury to the volar plate complex.

As previously emphasized, treatment of complete injuries is somewhat controversial. Even incomplete lesions, however, require casting or custom splinting for several weeks. All patients should be referred to an orthopedist for definitive care. Treatment in the ED should consist of the application of a thumb spica splint leaving the distal joint free to flex. This is crucial as the IP joint will start to scar early in the healing process unless it is free to move.

Closed Fist Injuries. Closed fist injuries result from striking another individual in the mouth region with the fist; such blunt impact on the aggressor’s hand likely produces soft-tissue and bony injury to the hand. If the soft-tissue injury includes a break in the integrity of the skin on the dorsum of the hand, infection may complicate the original injury. As such, these injuries should be approached with great respect.

Although these injuries are common, they are frequently mismanaged. Mismanagement results from a number of factors. Patients who suffer these injuries are often intoxicated, making an adequate history and thorough examination difficult. They may also be reluctant to reveal the cause of injury and provide misleading histories. The physician must have a high index of suspicion in any injury where there are lacerations, abrasions, or bruising over the metacarpophalangeal joints. Closed fist injuries fall into two basic categories: 1.) those that involve the bony structures; and 2.) those with open wounds. Closed fist injuries with open wounds are among the most dangerous because they usually involve a human bite—the so-called fight-bite wound.

Metacarpal Head Fractures. These intra-articular fractures result from significant impact force on the fist.[11] These bony injuries more commonly occur in the index and long fingers; the fractures are usually comminuted. Fractures are frequently missed on the radiograph as the focus of attention is often on the metacarpal shaft. Additionally, they are difficult to see on the lateral view because of overlap of the metacarpal heads. Oblique radiographs are often very useful in identifying the fracture as well as the degree of comminution.

These are intra-articular fractures and can lead to early joint arthrosis if not properly diagnosed and managed. These injuries should be treated with a splint that immobilizes the metacarpophalangeal joint in 70-90° of flexion. Unquestionably, the most common and clinically significant error made in treating these fractures in the ED is poor positioning of the metacarpophalangeal joints in the splint. Meticulous attention to proper splinting is mandatory for the clinician in that improper splinting allows the ligaments to remain in a relaxed position; such lax ligaments may result in contractures at the MP joint and represent one of the most difficult problems faced by the hand surgeon.[12] Early referral to an orthopedist after splinting is appropriate.

Metacarpal Neck Fractures. Fractures of the metacarpal neck represent the most common associated fracture in the patient with a closed fist injury. Fracture of the fifth metacarpal neck, the "boxer's fracture," is the most frequently encountered "closed fist" bony injury. Fractures of the metacarpal neck are generally unstable because of volar comminution, more so for the radial metacarpals than the ulnar bones. The two radial metacarpals can tolerate almost no residual angulation without functional loss, while the ulnar two digits can tolerate some angulation without functional problem. These fractures can again be difficult to assess adequately on a lateral x-ray because of overlap; oblique views may be helpful. Associated CMC joint injury is common in patients with metacarpal neck fracture. Metacarpal neck fractures should be treated acutely in the same manner as the metacarpal head fractures. A splint with the metacarpophalangeal joints held in 70-90° of flexion should be applied and the patient referred for definitive orthopedic care.

Metacarpal Shaft Fracture. Metacarpal shaft fractures present more of a treatment challenge to the orthopedist than the neck fracture; yet, from the standpoint of the emergency physician, they can be treated in similar fashion. It should be noted, however, that associated carpometacarpal joint injuries are more common with these fractures and should be suspected and aggressively ruled out.

Metacarpal Base Fractures. Fractures of the base of the metacarpal are commonly missed. The overlap of the metacarpal bases on standard radiographic views can make it difficult to detect these injuries; oblique views will confirm the diagnosis if the AP films are equivocal.[13] Physical examination, however, with demonstration of the area of maximum tenderness should suggest to the physician the probability of the injury. Early diagnosis and referral for treatment will usually lead to a satisfactory result. These injuries should be treated with the standard metacarpal splint with the metacarpophalangeal joints flexed downward.

Fight-Bite Wounds Complicated by Infection. Human saliva contains as many as 42 species of bacteria with a microbe concentration of 1×10^8 organisms/mL.[14,15] Fist-to-mouth contact is perhaps the most common cause of human bite wounds. These fight-bite wounds have the highest incidence of complications of any closed fist injury and of any type of bite wound. These injuries usually occur over the dorsal aspect of the third, fourth, or fifth metacarpophalangeal joints, an area that is susceptible to deep infection because the thin skin overlying the joint provides little protection to the underlying ligaments, synovium, and cartilage.[16] Joint space infections resulting from a human bite wound are aggressive and rapidly destructive. They usually occur in young people, and the resulting destructive changes of the MP joint can be devastating as there is no good surgical option to reconstruct the MP joint of a young person. For these reasons, it is a commonly accepted axiom in the world of hand surgery that all open wounds over the metacarpophalangeal joints are considered to be probable fight bites; such an approach will ensure that all patients will receive appropriate therapy.

The wound must be thoroughly explored to rule-out joint capsule violation as well as a retained foreign body, such as a tooth fragment or piece of jewelry. The wound should be copiously irrigated. If the joint space was violated, this area should be thoroughly irrigated as well. After aggressive care has been completed, the wound should be left open (i.e., no primary closure should be attempted in that such an approach will increase the possibility of infection). Further, the patient should receive a parenteral, broad-spectrum antibiotic in the ED with continued outpatient oral antimicrobial agents. Early follow-up (at 24-48 hours) with a physician skilled in the management of such injuries is encouraged. If the patient appears noncompliant, consideration should be made for initial inpatient care. Early range of motion is initiated and the wound is allowed to heal secondarily or closed as a delayed primary closure. Improper initial care—frequently due to either the lack of physician knowledge of the potential infectious complications or patient claims stating the wound did not occur with fist-to-mouth contact—will result in significant hand infection with deep space penetration and purulent tenosynovitis. *(See Figure 23.)*

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Physician CME Questions

65. What percentage of posterior dislocations are incorrectly diagnosed and/or poorly managed at the time of the initial encounter?
    A. Less than 10%
    B. 20%
    C. 30%
    D. 40%
    E. More than 50%

66. According to the article, posterior glenohumeral dislocations generally occur when the arm is:
    A. foward flexed and internally rotated
    B. externally rotated and not flexed.
    C. forward flexed and externally rotated.
    D. not flexed and internally rotated.
    E. None of the above

67. Which of the following specific radiographic signs seen on the routine AP view points toward posterior glenohumeral dislocation?
    A. Absence of the normal eliptical shadow
    B. Vacant glenoid sign
    C. The trough line
    D. Hollowed out or cystic humeral head
    E. All of the above

68. According to the article, supracondylar fractures are rare after the patient reaches which age?
    A. 7
    B. 9
    C. 11
    D. 15
    E. None of the above

69. On the palmar aspect, which of the following visible landmarks defines underlying anatomy in wrist injuries?
    A. Lister's tubercle
    B. Lunotriquetral junction
    C. Distal wrist crease
    D. Radial styloid
    E. All of the above

70. What is the most common form of carpal instability?
    A. Distal radioulnar dislocation
    B. Scapholunate dissociation
    C. Scaphoid fracture
    D. Hook of the hamate fractures
    E. None of the above

71. According to the article, which is the most definitive study in identifying hook of the hamate injuries?
    A. Carpal tunnel view
    B. CT scan
    C. AP views
    D. Lateral views
    E. None of the above

72. The radiographic series for assessing dislocations of the carpometacarpal joint should include:
    A. AP views.
    B. lateral views.
    C. oblique views.
    D. All of the above

In Future Issues

Orthopedic Pitfalls: Part II

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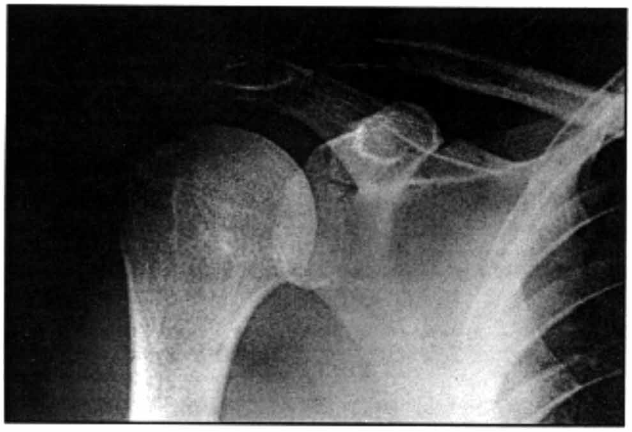
Visual Glossary: Figures 1-23

Orthopedic Injuries: Upper Extremity Fractures and Dislocations

(Enclosed for use with the April 26, 1999 issue)

Figure 1



Normal AP view of the glenohumeral joint. Note the overlap shadow of the humeral head superimposed on the glenoid rim—this overlap is lost in the posterior shoulder dislocation.

Figure 2

Posterior shoulder dislocation. AP radiograph of a posterior shoulder dislocation. This film could easily be interpreted as normal if some form of lateral radiograph is not obtained. On the routine AP view, there is usually an overlap shadow created by the head of the humerus superimposed on the glenoid fossa. The shadow is a smooth bordered ellipse. In posterior dislocations, the articular surface of the humeral head is posterior to the glenoid and the elliptical overlap shadow is distorted. Also note that the glenoid appears partially vacant—the so called "rim sign." Finally, note the hollowed out appearance of the humeral head.

Figure 3

Posterior shoulder dislocation with double cortical line or trough line. A trough line is noted on the AP radiograph, the result of the impaction fracture of the humeral head caused by the posterior rim of the glenoid; it is analogous to the Hill-Sachs impaction fracture seen in anterior dislocations. Radiographically, two parallel lines of cortical bone are visible on the medial cortex of the humeral head. One line represents the medial cortex of the humeral head, while the other represents the margin of an impaction fracture.

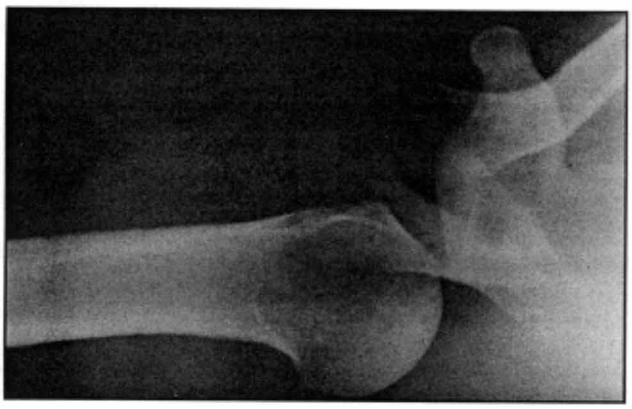
Figure 4

Posterior shoulder dislocation with hollow or cystic humeral head. In posterior dislocation, the arm is locked in internal rotation. The x-ray beam, therefore, passes through both the greater and lesser tuberosities, creating the image of a hollow or cystic humeral head. Also note the increased overlap of the humeral head on the glenoid.

Figure 5

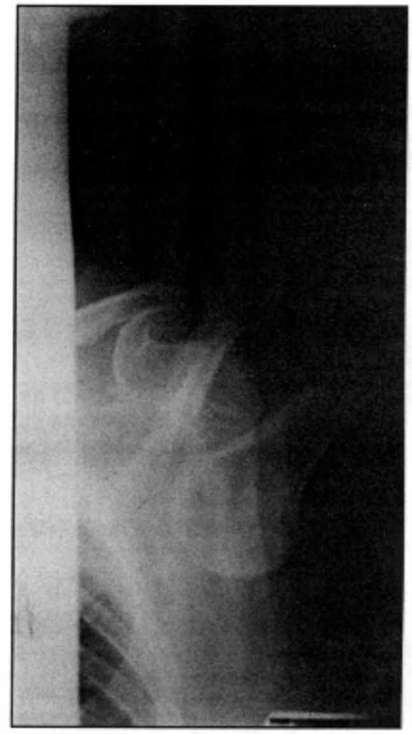
Posterior shoulder dislocation. Scapular lateral radiograph of a posterior dislocation. The glenoid is clearly visible at the junction of the stem and apex of the upper fork of the "Y." The humeral head is clearly not centered in the glenoid.

Figure 6



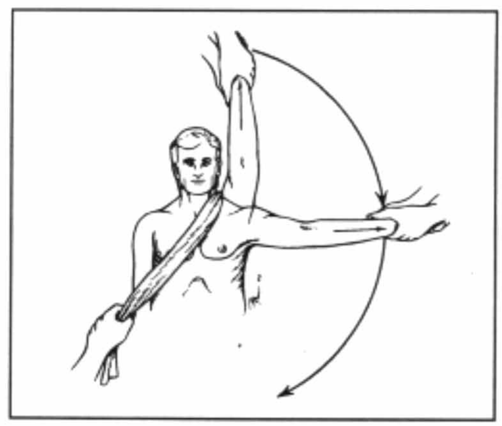
Posterior shoulder dislocation. Axillary lateral view of a posterior dislocation. The humeral head is clearly posterior to the glenoid.

Figure 7A



Inferior shoulder dislocation. Left shoulder radiograph demonstrating inferior dislocation of the humeral head. Note the inferior position of the humeral head relative to the glenoid. The arm is hyperabducted at the shoulder.

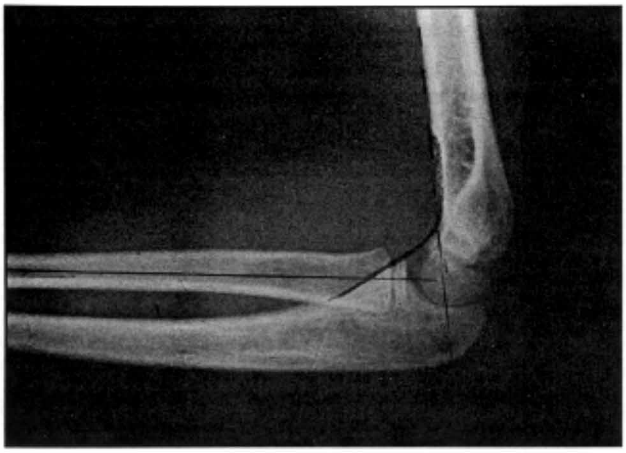
Figure 7B



Reduction technique in the patient with inferior glenohumoral dislocation. The patient is placed in the supine position and given intravenous sedation, analgesia, and muscle relaxation. In-line traction is applied to the fully abducted arm while firm cephalad pressure is maintained on the humeral head. Counter-traction is used with a rolled bed sheet placed superior to the shoulder. When the humeral head is reduced into the glenoid fossa, the arm is adducted toward the body and the forearm supinated.

Reproduced with permission from Brady WJ, Knuth CJ, Pirrallo RG. Bilateral inferior glenohumeral dislocation: Luxatio Erecta, an unusual presentation of a rare disorder. *J Emerg Med* 1995;13:37-42.

Figure 8



The anterior humeral line. The anterior humeral line is useful in evaluating possible supracondylar fracture in the pediatric patient. A line is drawn along the anterior aspect of the distal humerus extending through the elbow. In the normal state, the line will bisect the middle third of the capitellum.

Figure 9

The child with supracondylar fracture. In the child with supracondylar fracture, this line will either strike the anterior third of the capitellum or miss it entirely—anterior to the capitellum.

Figure 10

Fat pad signs. The anterior fat pad is often present in the normal patient as a narrow strip of radiolucency along the distal humerus; the posterior fat pad is not seen in the uninjured patient. With fracture about the elbow involving intra-articular structures, hemorrhage and/or edema fluid will distend the joint capsule and displace the fat out of the bony concavities, producing the radiographically evident fat pad signs. The abnormal anterior fat pad is seen here as a triangular structure resembling a sail boat spinnaker sail along the anterior aspect of the distal humerus. The appearance of a posterior fat pad of any morphology is considered abnormal. The presence of a fat pad should prompt the emergency physician to strongly consider an occult fracture—particularly the incomplete supracondylar fracture in a child or the adult radial head fracture (as seen in this example).

Figure 11

Radial head fracture. Undisplaced radial head fractures are difficult to detect radiographically. The normal cortex of the radial head is smooth with a continuous concave morphology. Any irregularity of the radial head, particularly in association with an abnormal fat pad, is a radial head fracture until proven otherwise. An abnormal anterior fat pad (triangular shape) is seen here as well.

Figure 12

Occult scaphoid fracture. AP view of the wrist in ulnar deviation taken at the time of injury. Note that there is no fracture line visible. Despite a suggestive mechanism (FOOSH) coupled with anatomical snuffbox tenderness, the patient was not appropriately treated for a scaphoid injury (thumb spica splint and orthopedic follow-up). The undiagnosed, radiographically occult scaphoid fracture resulted in chronic pain and ultimate functional instability of the wrist due to nonunion, as noted in Figure 13.

Figure 13

Initially occult scaphoid fracture with ultimate nonunion. Patient from Figure 12 presented several months later complaining that the "sprain" had never gotten better. Note the established nonunion.

Figure 14A

Scapholunate dissociation. Widening of the scapholunate gap to greater than 3 mm, the Terry Thomas sign, is an indicator of scapholunate dissociation, which is best visualized on a supinated AP or clenched fist AP view.

Figure 14B

AP of the wrist demonstrates a scapholunate dissociation. Note the increased scapholunate gap, the flexed position of the scaphoid, the cortical ring sign, and the trapezoidal shape of the lunate.

Figure 14C

Lateral view of the wrist in scapholunate dissociation. Note the increased scapholunate angle and the extended position of the lunate relative to the radius and the capitate.

Figure 15

Distal radioulnar joint dislocation. AP view of the wrist in a volar DRUJ dislocation. Note the narrowed appearance of the wrist and the empty appearance of the sigmoid notch.

Figure 16

Distal radioulnar joint dislocation. Lateral of the wrist from Figure 15. Note that the ulna is clearly volar to the radius and is in line with the pisiform—an abnormal position for the ulna on the lateral wrist projection.

Figure 17

Carpometacarpal (CMC) dislocation. The gross deformity of the subluxed or dislocated joint is often obscured by the severe swelling present on the dorsum of the hand. An obvious step-off deformity may be observed and/or palpated at the level of the dislocation (i.e., note the proximal end of the metacarpal as it overrides the distal carpus).

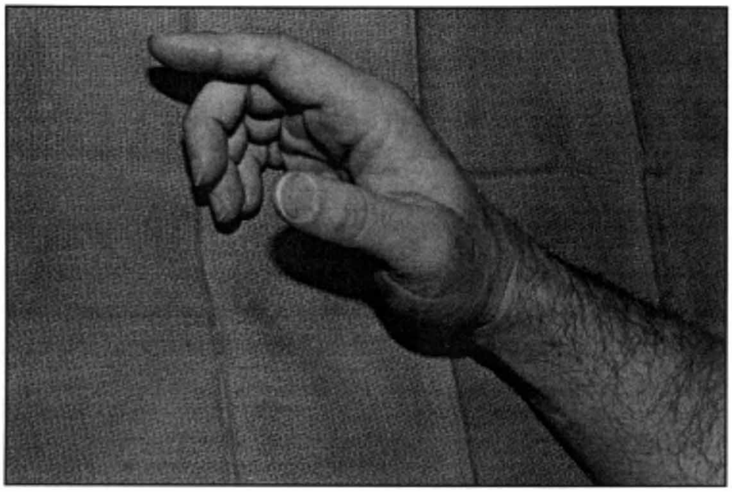
Figure 18

CMC dislocation. AP view of the hand from the patient seen in Figure 17 demonstrating CMC dislocation of the fifth metacarpal-carpal interface. The loss of the joint space is seen here.

Figure 19

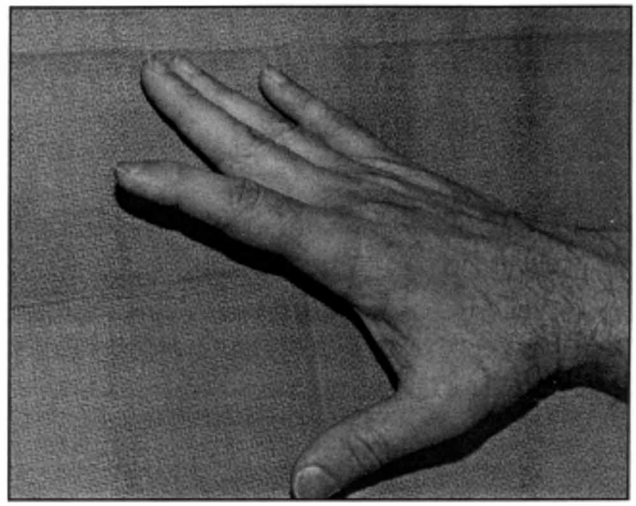
CMC dislocation. Lateral view of CMC dislocation from Figure 18 revealing obvious dorsal displacement of the proximal portion of the fifth metacarpal.

Figure 20



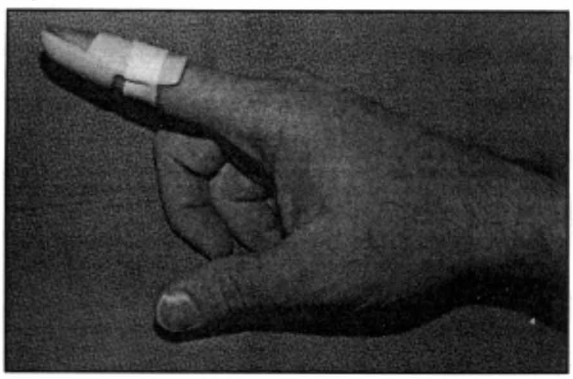
Flexor digitorum profundus rupture. On clinical examination, the patient will have inability to flex the distal IP joint actively when the proximal IP joint is blocked in extension; loss of the normal flexion cascade is seen with the involved digit remaining in either partial or complete extension in comparison to the other fully flexed digits.

Figure 21



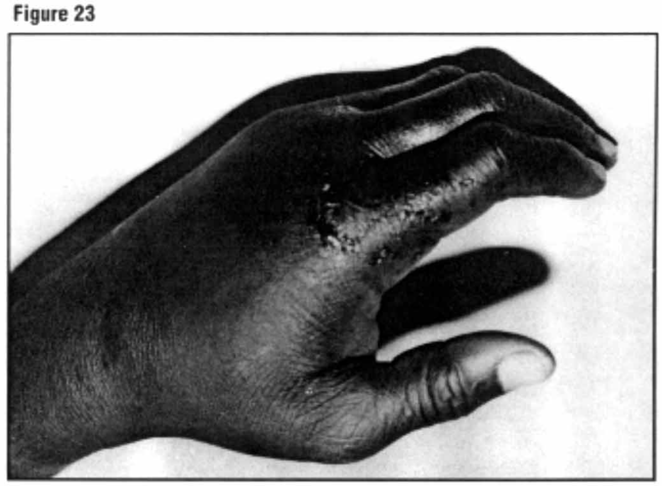
Mallet finger. Mallet finger is produced by a closed injury resulting in disruption of the distal extensor apparatus of the digit and manifested by a flexion deformity at the distal IP joint. Acutely, patients may have ecchymosis over the dorsum of the distal IP joint and always demonstrate an extensor lag at the distal IP joint.

Figure 22



Mallet finger. Soft tissue mallet fingers should be immobilized in extension continuously for eight weeks.

Figure 23



Closed fist injury with hand infection due to fight bite wound. Human saliva contains as many as 42 species of bacteria. Traumatic injury with joint space and/or deep space involvement will produce an infection that is aggressive and rapidly destructive. Improper initial care results in significant hand infection with deep space penetration and purulent tenosynovitis as seen here.