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Elbow Injuries and Fractures

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Abstract
Elbow complaints are frequently encountered in the emergency setting. Mechanism of injury often involves direct trauma or a fall on the outstretched hand and arm. Abnormal findings on elbow radiographs can be challenging to identify, thus a systematic approach is essential to identify subtle findings especially with occult fractures. Maintaining a high index of suspicion, identification of normal and abnormal fat pad signs, and proper alignment of specific anatomical lines on elbow radiographs can assist in the identification of hidden fractures. **Key words:** anterior humeral line, elbow fractures, fat pads, radiocapitellar line

ELBOW fracture is a generic term used in the description of a number of different fracture types for patients who present to emergency settings with elbow injuries. With all of these fractures, the commonality lies in the presentation of pain and acute swelling at the elbow. In most cases, the patient will resist movement.

There are many classifications of fractures occurring around the elbow. The most common types of "elbow fractures" include supracondylar fractures of the distal humerus, radial head fractures, olecranon fractures, and Monteggia fractures, which are defined as a combination of a radial head dislocation with a fracture of the proximal ulna. Although the radiographic features are distinct for each fracture type, the initial evaluation, intervention, and management essentially are the same. The treatment of patients with elbow injuries is based on fracture management principles that include the evaluation of the bone and joint, recognition and appropriate management of concurrent soft tissue and neurovascular compromise, immobilization of the affected limb, and timely x-rays for definitive diagnosis and further conservative or surgical management.

SPECIAL CONSIDERATIONS IN PEDIATRIC ELBOW INJURIES

In pediatric patients with open epiphyses, there is also the need to consider the long-term consequences of disruption of

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the growth plate. This disruption may elude radiographic detection because of the lack of ossification at the end of long bones, such as the humerus and the radius. Therefore, there needs to be a strong suspicion of growth plate involvement in supracondylar fractures, the most common pediatric elbow fracture (Ryan, 2011). There are several different classification systems for physeal injuries; however, the simplest and most widely used method of classification is the Salter–Harris system (see Table 1).

Involvement of the growth plate occurs in 20%–25% pediatric fractures, thus it is important to be familiar with the Salter–Harris classification system (Eiff & Hatch, 2003).

Although adult elbow fractures are often seen in the emergency setting, elbow fractures are more common in children, and the mechanism is typically a fall onto an outstretched arm. However, basic differences between adult and pediatric musculoskeletal injuries should be noted:

1. Adults have less elastic ligaments and tendons and are therefore prone to tears, sprains, and strains, whereas children generally have stronger soft tissues in comparison to their immature and softer bones and subsequently have increased incidence of fracture with impact;
2. Children have a periosteum (the outer covering of the bone) that is much more vascular and more metabolically active than in the adult. As a result, children will heal the fracture at a faster rate, making it imperative that the bone is in proper anatomic alignment as the bone rapidly remodels (Staheli, 2001). Delayed or nonunion is a rare occurrence in the pediatric patient, but malunion is a common fracture complication.

CLINICAL ELBOW ANATOMY

Bones

The elbow is comprised of three bones: 1) the humerus (long bone proximal to the joint, 2) the radius (lateral forearm), and 3) the ulna (medial forearm) which lies distal to the elbow joint. In actuality, there are three articulation points at the joint: the humeroulnar joint, the humeroradial joint, and the radioulnar joint. The joints are stabilized by the triangular fibrocartilage complex. The interosseous ligament runs between the radial and ulnar bones. Clinically important bony landmarks include the olecranon process, the capitellum, and the radial head, because all are potential sites for fractures.

Examination of the elbow injury begins with inspection and gentle palpation of both the bones and the soft tissues, which include the skin, nerves, and blood supply to the forearm and hand. Because the elbow is a hinged joint, range of motion is limited to flexion and extension (0°–135°), supination (90°), and pronation (90°). When a fracture is suspected, it is not recommended that range of motion be tested prior to radiographic studies.

Skin

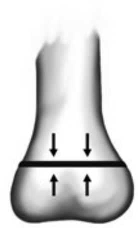
As with all trauma patients, the skin and soft tissues of both the elbow joint and the forearm should be assessed for the presence of acute hemarthrosis (bleeding into the joint), effusion, swelling, tenseness (compartment syndrome) pallor, coolness, tenderness, or breaks in the integrity of the skin due to an open injury.

Nerve Supply

The ulnar nerve is located at the groove between the medial epicondyle and the olecranon process. The ulnar nerve runs distally into the ring and little finger of the hand. Ulnar nerve compromise is manifested by weak thumb adduction and/or paresthesias in the fingers of ulnar nerve distribution (e.g., ring and little fingers).

The median nerve lies in the antecubital fossa medial to the brachial artery and transverses the forearm in to the hand. Neuropathic compromise to the median nerve results in paresthesias in the thumb, index, and middle fingers. The musculocutaneous nerve lies on the lateral side of the biceps

Table 1. Salter–Harris classification

Type I		**Transverse fracture through the physis that widens but does not directly affect the growth portion**
Type II		**Fracture line through the physis and the metaphysis; epiphysis is not affected**
Type III		**Fracture through the physis and the epiphysis**
Type IV		**Fracture through physis, metaphysis, and epiphysis (intra-articular fracture)—*can result in joint deformity***
Type V		**Crush injury of the epiphyseal plate—*can result in growth disturbance***

tendon and provides sensation to the forearm (Hoppenfeld, 1976).

The radial nerve has both a deep and a superficial branch that innervates the anconeus, brachioradialis, and extensor forearm muscles. Injury to the radial nerve will result in weak or absent wrist extension. In the radial tunnel, at the level of the radiocapitellar joint, the nerve divides into two branches: the deep (motor) radial nerve and the superficial (sensory) radial nerve (Boles, Kannan, & Cardwell, 2000). Numbness along the course of any of the nerves in the forearm or weakness at the wrist or fingers should be documented on all patients.

Blood Supply

The brachial artery originates beneath the teres major muscle and bifurcates into the ulnar artery and the radial artery at the level of the antecubital fossa of the elbow. Fractures of any of the bones in the upper extremity carry the potential for vascular compromise either due to soft tissue swelling and compression or arterial dissection from a fracture. Vascular status (e.g., checking pulses, skin color, pallor, capillary refill) should be assessed upon initial evaluation and throughout the course of diagnosis and treatment.

Ligaments and Tendons

The elbow is supported by the medial collateral ligament (MCL), which is prone to injury with sudden valgus (outward-extension) stress (Hoppenfeld, 1976). The lateral collateral ligament is located on the radial side of the elbow and can be traumatized by sudden varus (inward-flexion) stress (Hoppenfeld, 1976). The annular ligament is attached to the lateral collateral ligament and covers the radial head and neck.

PHYSICAL ASSESSMENT

Prior to radiographs, assessment should be limited to evaluation of pain and inspection of any deformity. It is important to move the affected limb as little as possible. Elicited tenderness at the olecranon or capitellum may be noted, but is not necessary for definitive diagnosis. It is most important, that the neurovascular examination is documented on initial assessment, before any x-rays have been obtained, and then repeated after any procedures or manipulation. Additionally, because elbow and forearm injuries can be complicated by compartment syndrome, the distal extremity should be evaluated for swelling and sequential neurovascular examinations documented. Repeat neurovascular examinations are essential to rule out compartment syndrome. Compartment syndrome is a cascade of events that is initiated by soft tissue swelling that impairs blood outflow. Because the limb is deprived of oxygenated blood, the muscles and nerves in the forearm become ischemic and will become necrotic if blood supply is not restored through decompression within 6 hours (Rasul, 2011). See Table 2 for signs suggestive of compartment syndrome.

ELBOW RADIOGRAPHS

Basic Radiographs: Anteroposterior and Lateral

The basic radiographs of the elbow include the anteroposterior (AP) and lateral views. Most elbow fractures are readily recognized on these radiographs. The elbow is held in full extension for the AP view. The capitellum articulates with the radial head laterally and the trochlea articulates with the ulna medially on the AP view (Figure 1). On the AP view, the olecranon is not visible. On the lateral view, the elbow is held in 90° of flexion (Figure 2). In this view, the capitellum and trochlea are superimposed. The lateral view is examined for presence or absence of fat pads.

Table 2. Signs suggestive of compartment syndrome

Deep burning pain out of proportion to the injury
Worsening pain with elevation of the limb or passive stretching of the muscles adjacent to the injury
Numbness and tingling along the distribution of local nerves
Weakness or paralysis of the involved limb
Loss of arterial pulse distal to the injury

Figure 1. X-ray of normal anteroposterior (AP) view. The elbow is held in full extension. The capitellum articulates with the radial head laterally; the trochlea articulates with the ulna medially. The olecranon is not visible.

Figure 2. X-ray of normal lateral view with the elbow held in 90 degrees of flexion. The capitellum and trochlea are superimposed. The lateral view is examined for presence or absence of fat pads.

Oblique View

Oblique views may be helpful, especially in children, when the AP and lateral views do not show a fracture, yet abnormal fat pad is present. The external oblique view is an angled lateral view can be utilized to identify occult radial head and other elbow fractures (Bohndorf & Kilcoyne, 2002). Oblique views are also helpful to identify lateral condyle fractures.

Fat Pads

There are anterior and posterior fat pads in the elbow. A fat pad is a mass of fat cells that are closely packed together and surrounded by fibrous tissue. Fat is normally contained in the joint capsule of the elbow. This fat is usually concealed behind the olecranon and coronoid fossae. Anterior and posterior fat pads can be seen on the lateral view of the elbow. A fat pad appears as a gray or black area in the soft tissue on the lateral elbow radiograph. There are normal and abnormal fat pads in the elbow. An anterior fat pad that is closely adherent to the distal humerus is normal on the lateral view (Figure 3). When there is an elbow injury that causes distention

Figure 3. Normal anterior fat pad. An anterior fat pad that is closely adherent to the distal humerus is normal on the lateral view.

Figure 4. Abnormal anterior sail sign (right) and posterior fat pad (left). Radiolucent shadows in the anterior and posterior areas of the distal humerus will be seen. Abnormal anterior fat pad "sails away" (right) from distal humerus, indicating intra-articular hemorrhage. Posterior fat pad (left) is always abnormal.

of the synovium from traumatic hemarthrosis, it causes radiolucent shadows in the anterior and posterior areas of the distal humerus. An abnormal anterior fat pad "sails" away from the distal humerus, appearing like the sail of a boat or no longer being closely adherent to the humerus, indicates intra-articular hemorrhage. A posterior fat pad is always abnormal and signifies a joint effusion often associated with an elbow fracture, usually the radial head in the adult patient (Figure 4). A lateral elbow radiograph with no elbow fracture identified, yet abnormal fat pads on the lateral film, indicates an occult elbow fracture (Figure 5). The lack of an abnormal fat pad does not exclude an elbow fracture. Any fluid accumulation in the elbow joint can result in a positive fat pad such as septic arthritis and gout. Injuries that tear the joint capsule, such as elbow dislocations or fractures, usually do not cause a fat pad sign because the synovium of the joint is no longer intact, thus the effusion has leaked into the soft tissues outside the joint capsule.

Lateral Elbow Radiograph: Anterior Humeral Line

When examining the lateral elbow radiograph, a line can be drawn along the anterior humeral line (Figure 6). Approximately one

Figure 5. X-ray of lateral elbow with abnormal fat pads. A lateral elbow radiograph with no elbow fracture identified but abnormal fat pads on the lateral film indicates an occult elbow fracture. NOTE: However, the lack of an abnormal fat pad does not exclude an elbow fracture.

third of the capitellum should lie anterior to this line (Raby, Berman, & deLacy, 2001). If less than one third of the capitellum lies in front of the anterior humeral line, a supracondylar fracture may be present with the capitellum displaced posteriorly (Figure 7). This rule does not always apply in pediatric patients when the capitellum is not completely ossified.

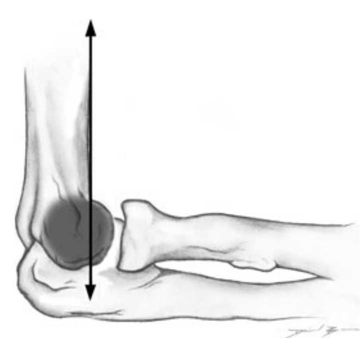


Figure 6. Normal anterior humeral line. Approximately 1/3 of the capitellum should lie anterior to this line.

Figure 7. Abnormal anterior humeral line. If < 1/3 of the capitellum lies in front of the anterior humeral line, a supracondylar fracture may be present with the capitellum displaced posteriorly. NOTE: This rule does not always apply in pediatric patients when the capitellum is not completely ossified.

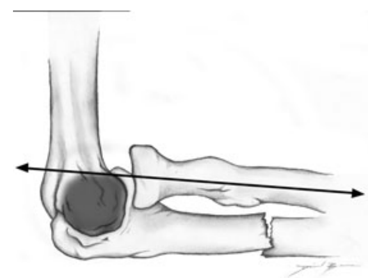


Figure 9. Abnormal radiocapitellar line. This drawing depicts a Monteggia fracture: proximal ulnar fracture and concurrent radial head dislocation. NOTE: The radiocapitellar line is often displaced from the center of the capitellum with a radial head fracture; if the line does not pass through the capitellum, a radial head dislocation should also be suspected.

Lateral Elbow Radiograph: Radiocapitellar Line

When examining the lateral elbow radiograph, a line drawn through the center shaft of the proximal radius should intersect with the center of capitellum (Figure 8). If the line does not pass through the capitellum, a radial head dislocation should be suspected (Figure 9; Raby et al., 2001).

ELBOW FRACTURES

Supracondylar Fractures

Approximately 60% of all pediatric elbow fractures are supracondylar fracture; these fractures carry a high risk for neurovascular compromise (Ryan, 2011). Supracondylar fractures generally occur when a child falls on an outstretched arm while engaged in climbing. Because the mechanism of injury is generally a fall from a high place, the patient should be assessed for concurrent trauma to the head and neck, chest, abdomen, back, pelvis, and other extremities. Supracondylar fractures are more common in children because of their relatively weak and immature bone. These fractures are more common because of the relatively weak and thin bone in this region during childhood. They may displace either posteriorly or anteriorly, thus impinging or lacerating the brachial artery. A transient loss of nerve function may be noted, particularly along the median nerve when there is posterolateral displacement of the fracture.

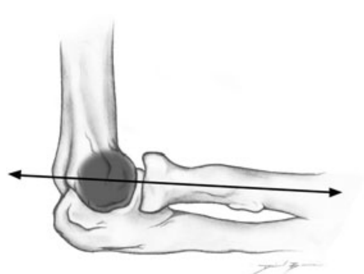


Figure 8. Normal radiocapitellar line. A line drawn through the center shaft of the proximal radius should intersect with the center of capitellum.

On physical examination, ask the patient to make an "OK" sign with his thumb and index finger to assess median nerve function. Posteromedial displacement of the fracture may compromise the radial nerve. This can be assessed by asking the patient to extend his wrist or his thumb. The ulnar nerve can be assessed by asking the patient to spread his fingers or flex his little finger. Brachial artery injury should be suspected by the presence of ecchymosis in the anteromedial aspect of the forearm. Comparison of brachial and radial arterial pulses with the unaffected limb is important. Alternatively, pulse oximetry can be used to assess perfusion of the distal extremity.

As with all fractures, the clinician must be most cognizant of the signs and symptoms of compartment syndrome, an orthopedic emergency that warrants immediate measurement of compartment pressure and/or emergent orthopedic consultation (Ryan, 2011). In most cases, a supracondylar fracture will cause the anterior humeral line to be anterior to its normal location on the lateral view of the elbow with the distal humerus fragments being posteriorly displaced (Figure 10; Herring, 2007).

Appropriate analgesia is recommended before the extremity is radiographed for patient comfort and the limb should be immobilized because manipulation may increase the risk for neurovascular compromise. The arm should be splinted as outlined below and maintained in the presenting position. There should be no attempts to restore anatomic alignment prior to splinting unless there is evidence of neurovascular compromise. General splinting techniques are discussed herein. Orthopedic consultation should be promptly obtained for open fractures, signs of neurovascular compromise, and/or displaced fractures.

Figure 10. X-ray of distal humeral fracture. A supracondylar fracture will cause the anterior humeral line to be anterior to its normal location on the lateral view of the elbow with the distal humerus fragments being posteriorly displaced.

Radial Head Fractures

A radial head fracture is the most common elbow fracture occurring in adults (Figure 11). The mechanism of injury is generally a fall on an outstretched hand that results in the head of the radius being driven into the capitellum. It may be associated with concurrent fractures of the capitellum or the distal radius, disruption of the MCL, elbow dislocation, or triceps tendon rupture. The "Terrible Triad" injury is described as a radial head fracture plus MCL tear plus coronoid process fracture (Wheelus, 2011). The elbow should be examined for tenderness over the radial head or crepitus over the radial head with supination. When a radial head fracture is suspected, one should examine the lateral elbow radiograph for positive fat pad sign consisting of either an anterior sail or a posterior fat pad. If a fracture is not seen on the AP and lateral view, an oblique view should be ordered if the patient is tender over the radial head (Stead, Kaufman, Stead, Bhagra, & Dajani, 2009). The radiocapitellar line is often displaced from the center of the capitellum (see Figure 9).

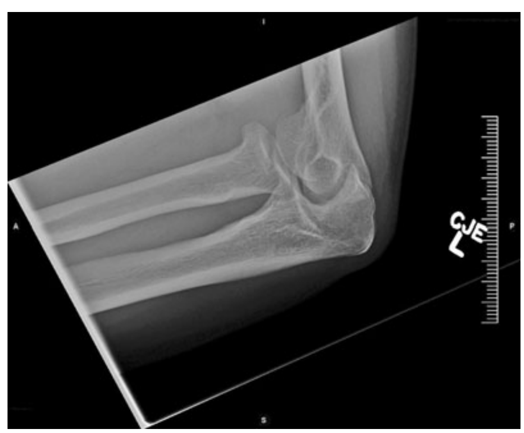


Figure 11. X-ray of radial head fracture in an adult. Radial head fracture is the most common elbow fracture in adults.

Olecranon Fractures

Olecranon fractures can be divided into two categories: low energy and high energy. Generally, low-energy fractures occur in the elderly population as a result of a sudden pulling injury to the triceps and brachialis muscles at the same time. High-energy fractures are the result of high-impact direct trauma to the olecranon process with a concurrent comminuted fracture of the ulnar shaft. These fractures can also occur as a result of repetitive stress and microtrauma as seen in baseball pitchers. The most common long-term complication of this injury is stiffness, which can be prevented with appropriately timed therapy (Agnihotri, 2011). This injury is often easily identified on the lateral elbow radiograph. At times, the olecranon fragment can be significantly displaced (Figure 12).

Monteggia Fractures

A Monteggia fracture is actually two orthopedic injuries that occur simultaneously: a proximal ulnar fracture and concurrent radial head dislocation (see Figure 9; Miller, 2008). This injury is a fracture-dislocation injury, which often occurs when one receives a blow on the forearm when one is trying to protect oneself (Ouellette & Tetreault, 2003). The Monteggia fracture injury may occur as an isolated injury or as part of a complex injury pattern that involves an olecranon fracture-dislocation, radial head fracture, coranoid fracture, and lateral collateral ligament injury with subsequent instability (Ring, Jupiter, & Waters, 1998). The Monteggia injury fracture presents a diagnostic challenge as the radial head dislocation is often missed on x-ray. One must be diligent to examine the entire radiograph and not be distracted by only the fracture component of this elbow injury. These fractures occur, like most elbow fractures, as a result of a fall on an outstretched hand with forced pronation and may accompany any ulnar fracture. In pediatric patients with immature bones, less attention is focused on the direction of the radial head displacement and more emphasis is placed on the type of ulnar fracture which can range from a greenstick fracture to a displaced comminuted oblique fracture (Putigna, 2011). The appearance of the elbow and the presenting complaints of pain, paresthesia, swelling, and crepitus are similar to the previously described fractures. Special attention must be given to radial nerve function because this is the most common nerve entrapment related to the Monteggia fracture. Reduction of the radial head must be done within 6–8 hr of the injury to prevent further articular damage and/or nerve injury.

Figure 12. X-ray of olecranon fracture in an adult patient. Olecranon fractures can be identified on the lateral elbow radiographs. In this patient, the olecranon fragment is significantly displaced.

Radial Head Subluxation

Nursemaid's elbow or subluxation of the radial head is usually seen in children aged between 1 and 3 years (Broder, 2011). The mechanism of injury is usually a pulling or traction injury to the arm by an adult such as when the parent picks a child up by the arms or "swings" the child around using their arms. The annular ligament normally holds the radial head against the proximal ulna and capitellum (Figure 13). With this injury, the sudden traction is more force than the annular ligament can maintain, and thus the radial head becomes subluxed or partially dislocated from the elbow joint (Figure 14). The pediatric patient presents with the arm held in the recumbent position and does not want to move the arm by resisting supination of the wrist. Physical examination reveals no swelling of the elbow. The clavicle and wrist should also be examined. X-rays are usually not indicated in this circumstance, unless the mechanism of injury is unclear or other fracture concerns exist. Reduction is generally achieved by hypersupination of the hand and subsequent flexion of the elbow in one motion. The practitioner's finger held over the radial head will often feel a "pop" or click when the radial head is reduced. An alternative method is the pronation and flexion method. While the practitioner applies slight distal traction, the patient's wrist is hyperpronated, and rapid flexion at the elbow is performed in one motion. With both methods, the child should begin using the arm normally within a short period of time if the procedure is successful (Pfenninger & Fowler, 2011). If the injury occurred longer than 12 hours prior to presentation, the child may not move the arm initially after reduction procedure resulting in a delay in returning to normal movements of the elbow.

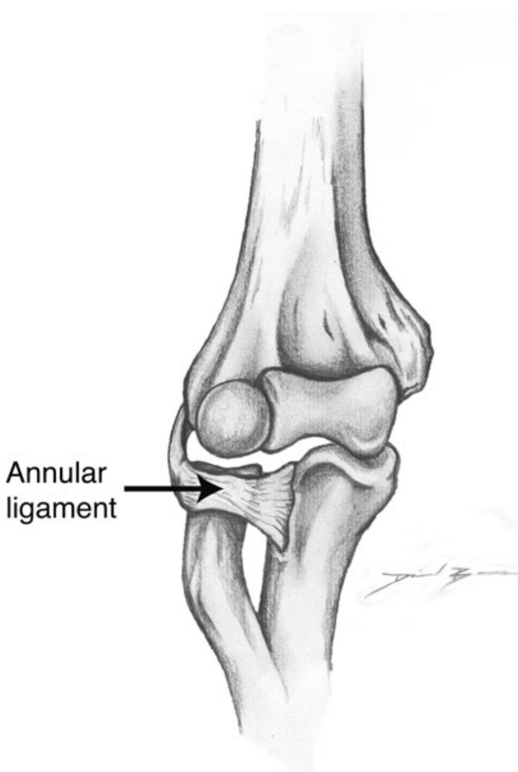


Figure 13. Annular ligament. The annular ligament holds the radial head against the proximal ulna and capitellum.

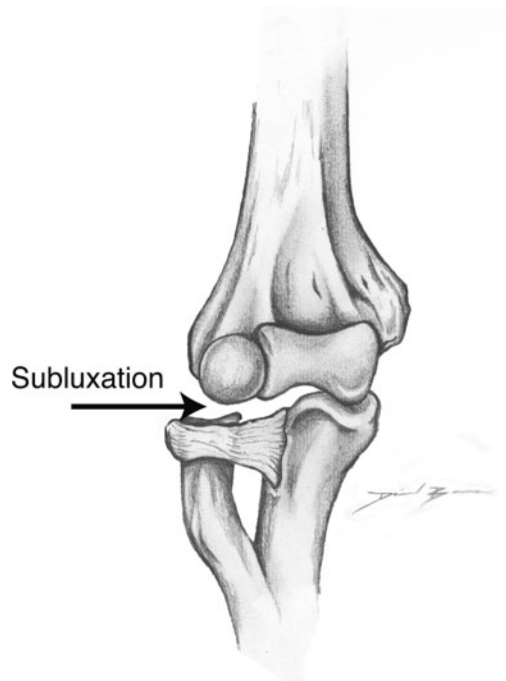


Figure 14. Radial head subluxation. Sudden traction is more force than the annular ligament can maintain, and thus the radial head becomes subluxed or partially dislocated from the elbow joint.

IMMOBILIZATION OF FRACTURES: SPLINTING

Splints are frequently used in the immediate posttraumatic period and for long-term immobilization of fractures. The use of a sugar tong splint is best for immobilizing the elbow and wrist. Splinting helps maintain bony alignment and prevents further injury and displacement of a fracture while the patient is undergoing diagnostic testing, and minimizes further neurovascular injury (Chudnofsky & Byers, 2008). Depending on the quality of the prefabricated splint, there may be a need for extra padding (e.g., Webril) over bony prominences. The splint should have excess water squeezed out before molding to the extremity. It is important that the splint is molded to the contour of the extremity and in anatomic position to prevent movement. Care must be taken to use the palm of the hand as the splint is contoured to avoid pressure points. Secure the splint in place using an elastic bandage. Prior to discharge, the extremity should be rechecked for adequate immobilization, swelling, and neurovascular status. Elbow injuries require long arm posterior splints to prevent flexion and extension, with minimal pronation and supination. This splint begins at the posterior aspect of the distal humerus and continues along the medial forearm to the metacarpals. The elbow is flexed at a 90° angle with the forearm and wrist maintained in a neutral position.

CONCLUSION

Elbow injuries require a systematic method for assessment of the elbow joint and radiographs. Some orthopedic providers may prefer comparison views. The lateral view radiograph is essential to evaluation for joint effusions and subtle fractures. Proper alignment of anatomical lines on elbow radiographs can assist with identification of subtle fractures.

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