Radiology of acute elbow injuries

Introduction

Elbow injuries are common and usually result from a fall onto an outstretched hand. Plain radiograph is the main modality used in the initial evaluation of these injuries. Clinical assessment can often be limited, especially in children who may be unable to communicate specific complaints and are sometimes difficult to examine reliably. Equally, interpretation of these radiographs is a daunting task as there are multiple ossification centres and normal variations. Therefore a good understanding of normal anatomy and common injury patterns is essential in evaluating elbow radiographs in the acute setting. This article reviews basic developmental anatomy, classical radiological signs and common elbow injuries.

Anatomy

The elbow is a hinge joint and therefore inherently stable. There are three articulations: humeroradial articulation, formed by the radial head and the capitellum of the humerus; the humeroulnar articulation, formed by the ulnar notch and the trochlea of the humerus; and the proximal radioulnar articulation, formed by the proximal part of the ulna and radius. The anterior fat pad lies anterior to the distal humerus and is seen apposed to the humerus, and the posterior fat pad lies posterior to the distal humerus and is never visible.

Growth and ossification of the elbow involves a series of complex epiphyseal and apophyseal centres. The acronym CRITOL describes the sequence of appearance of these growth centres (*Table 1*, *Figure 1*).

Radiological assessment and classical signs

The ABCS system of radiological assessment is followed for systematic evaluation (*Table 2*).

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Adequacy

The standard elbow series is made up of anterior-posterior and lateral projections. Occasionally oblique views may be helpful in assessing more occult injuries of the radial head and distal radius.

Alignment

On the anterior-posterior projection the radio-capitellar and coracoid trochlear joint space should be equal. The lateral projection is acquired with the elbow flexed at 90°. A symmetrical hour-glass sign is present on a true lateral radiograph.

Anterior humeral line

The anterior humeral line is drawn along the anterior aspect of the humeral shaft on the lateral radiograph (*Figure 2*). Only true lateral views should be used to assess this line. A supracondylar fracture changes the anterior humeral line as it passes through the anterior third or entirely anterior to the capitellum. Eccentric early ossification of the capitellum may give a misleading appearance and make this humeral line unreliable in children less than 2.5 years of age (*Table 3*).

Radio-capitellar line

This line is drawn through the middle of the radius and should bisect the capitellum on both the lateral and the anteroposterior elbow radiograph (*Figure 2*). If it does not, dislocation of the radial head or displacement of the capitellum should be suspected.

Bones

Fractures generally present as breaks in the cortex with displacement and angulations.

Table 1. Sequence of appearance of ossification centres

C	Capitellum (1–3 years)
R	Radial head (2–6 years)
I	Internal (medial) epicondyle (4–8 years)
T	Trochlea (7–12 years)
O	Olecranon (9–14 years)
L	External or Lateral epicondyle (10–12 years)

Table 2. ABCS system for radiological assessment

Adequacy
Alignment
Bones
Congruity
Soft tissue

Figure 1. a. Ossification centre for the capitellum (C). b. Appearance of radial head (R), internal epicondyle (I) and trochlea (T) by the age of 12 years. c. Development of olecranon (O) and lateral epicondyle (L).

The medullar trabecular pattern may also offer vital clues with lucent lines crossing the trabeculae representing the underlying fracture plane.

Congruity

This is particularly important in evaluating elbow injuries in children, because of the multiple ossification centres. Although the underlying bone may appear normal the joint can lose its symmetry and congruity in avulsion injuries. Therefore a good understanding of the developmental sequence of various ossification centres and correlation with the patient's age (CRITOL) is vital in assessing the congruity of the joint.

In children, avulsion of the medial epicondyle ossification centre is a frequently missed injury. Non-visualization of the medial epicondyle in the presence of a trochlear ossification centre should raise suspicion of a displaced or avulsed medial epicondyle. The radiograph should be scrutinized for the displaced medial epicondyle. Remember that the trochlear ossification centre always ossifies after the medial epicondyle.

Figure 2. The anterior humeral line (blue line) A-B is drawn along the anterior aspect of the humerus and normally passes through the anterior third of the capitellum. The radio-capitellar line is denoted by C-D (yellow line) and should bisect the capitellum in both views.

Table 3. Pitfalls in the interpretation of elbow X-rays

The anterior humeral line is not reliable in children, when the capitellum is poorly ossified
The radio-capitellar line should be assessed in the presence of ulnar shaft fracture as this can be associated with radial head dislocation, when it is called a Monteggia fracture
Absence of fat pad displacement does not rule out a fracture

Soft tissue

Anterior fat pad or sail sign

Following trauma, blood can accumulate in the intra-articular space and push the fat pad anteriorly forming the shape of a sail (*Figure 3*). A positive sail sign in the setting of trauma is a reliable indication of an intra-articular fracture – even if the fracture cannot be identified.

Posterior fat pad sign

Radiographic visualization of a posterior fat pad is never normal and always signifies fluid in the intra-articular space (*Figure 3*). In the setting of trauma, this strongly implies fracture of an articular surface.

Injuries

Fractures

Supracondylar fracture

This is by far the most common elbow injury in children, accounting for more than 50% of fractures of elbow in the 3–10 year age group. The mechanism of injury is either a fall on a hyperextended elbow with resultant extension-type fracture (*Figure 4b*), which accounts for 95% of supracondylar fractures, or a direct blow to the posterior aspect of the elbow causing a flexion-type fracture (*Figure 4c*) which is rare.

Figure 3. Elevation of the anterior and posterior fat pad indicating elbow joint effusion.

Intercondylar fracture

This is a T- or Y-shaped fracture with varying displacement between the condyles and the humerus. The mechanism is a direct blow, such as a fall onto a flexed elbow, driving the olecranon against the humeral articular surface separating the condyles. Patients usually present with marked tissue swelling holding their forearm in pronation and crepitus of movement when condyles are pressed together. These are associated with extensive neurovascular injuries.

Medial epicondylar fracture

The mechanism of injury is a fall directly onto the elbow or a fall on the outstretched arm in which the elbow is subjected to valgus strain. The flexor muscles of the forearm avulse the medial epicondyle from the humerus with displacement of the whole epicondylar epiphysis (*Figure 5*). This injury pattern is commonly associated with elbow dislocations and paresis of the ulnar nerve.

Lateral condylar fracture

This injury is sustained following a fall on an extended and abducted arm causing varus strain on the elbow (*Figure 6*). There

Figure 4. a. Wrinkle of the posterior cortex (white arrow) indicating an undisplaced supracondylar fracture. b. Extension-type supracondylar fracture as the anterior humeral line (yellow line) passes anterior to the capitellum. c. The distal fragment is displaced anteriorly resulting in a flexion-type supracondylar fracture.

Figure 5. a. Minimal displacement of medial epicondyle (white arrow). b. Avulsion of common flexor origin with fragmentation.

is avulsion of the common extensor tendon origin resulting in a Salter–Harris type IV injury with intra-articular extension.

Radial head and neck fracture

Radial head fracture is the most common type of elbow fracture in adults (*Figure 7*). It generally results from a hard fall on an outstretched hand. Radial neck injuries are more common in children and are often just a subtle wrinkle in the cortex. Although inherently a stable injury it can cause restriction in supination and pronation. It can also be associated with medial collateral ligament rupture and coronoid fracture forming the 'terrible triad'.

Olecranon fractures

The mechanism of an olecranon fracture is usually a direct blow or a fall onto an outstretched hand resulting in a transverse fracture line passing into the trochlear notch (*Figure 8*). There is displacement of fracture fragments as a result of unopposed force of the triceps at its insertion. Ulnar nerve injury is common in this injury pattern.

Dislocations

The frequency of elbow dislocations is second only to that of dislocations of the shoulder and is usually the result of high impact injury. The exception is isolated radial head subluxation in children resulting in a 'pulled elbow'.

Posterior dislocations

These account for 80–90% of all elbow dislocations (*Figure 9*). This injury pattern is associated with rupture of the joint capsule and disruption of the elbow stabilizers. Closed posterior dislocations are not commonly associated with neurovascular injury.

Anterior dislocation

This type of dislocation is rare and follows high energy impact to the elbow in a flexed position. This force drives the olecranon forward in relation to the humerus. Anterior dislocations and any open fracture

Figure 8. Displaced intra-articular olecranon fracture.

Figure 6. a. Lucency over lateral condyle. b. Avulsed fragment (white arrow) in the elbow joint resulting in fixed flexion block.

Figure 7. Intra-articular fracture (arrow) of radial head with elevation of posterior fat pad.

are commonly associated with disruption of the brachial artery and/or injury to the median nerve.

Monteggia fracture dislocation

This is a fracture of the proximal third of the ulna and proximal radio-ulna joint dislocation (*Figure 10*). The ulna fracture is quite prominent and attracts most of the focus. However, the radial head dislocation may not be apparent and will be missed if the elbow is not included in the radiograph. Therefore when a fracture of a long bone is noted, the joints above and below should be evaluated using radiographs in orthogonal planes. Early identification is essential to avoid complication like nerve injury, recurrent dislocation of the radial head, radio-ulnar synostosis, chronic pain and significant medicolegal implications. BJHM

Figure 9. Lateral view shows elbow dislocation with posterior displacement of the radius and ulna.

Figure 10. Proximal ulna shaft fracture (arrow) with posterior dislocation of radial head. Radio-capitellar line (yellow line) passes inferior to the capitellum forming Monteggia fracture dislocation complex.

Conflict of interest: none.

Further reading

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Schwartz DT, Reisdorff EJ (1999) *Emergency Radiology.* McGraw-Hill, New York: 84–93

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KEY POINTS

- The anterior humeral line crosses the middle third of the capitellum on a lateral radiograph.
- The radio-capitellar line should pass through the centre of the capitellum.
- A displaced anterior fat pad is highly suspicious of fracture, even in absence of an identifiable fracture.
- Visibility of the posterior fat pad is suspicious of fracture.
- CRITOL gives the sequence of appearance of secondary ossification centres.
- Look closely for medial epicondyle avulsion.