Interpretation of elbow and forearm radiographs

Introduction

Upper limb trauma is extremely common, with the elbow joint frequently injured. This usually occurs secondary to direct trauma or as a result of a fall onto an outstretched arm. Plain radiographs remain the first-line investigation in these patients, but interpretation can be difficult because of the variety of possible injuries, and their sometimes subtle appearances. Understanding of the anatomy, especially in the developing elbow, is key to avoiding errors in the management of these injuries. This article provides a systematic approach to interpreting elbow and forearm radiographs and describes the common conditions requiring these X-rays along with radiological signs.

Interpretation of elbow and forearm radiographs

The routine views of the elbow include a minimum of the anteroposterior (AP) and lateral. Additional oblique views are sometimes useful for further assessment of subtle injuries, particularly of the radial head. Forearm injuries, like any other long bones, require two views taken at 90°, for adequate assessment in the context of trauma.

Technical factors

Anteroposterior film: The AP radiograph is taken with the patient seated, the arm abducted and fully extended, with the X-ray beam centred over the elbow joint. Sometimes the patient is not able to fully extend the arm, and so AP views of first the humerus then the forearm may be obtained.

Lateral film: The lateral radiograph is taken with the arm flexed at 90°, and with the forearm in supination. Optimal lateral positioning is essential for interpretation as minor degrees of obliquity or rotation can obscure fat pad abnormalities and even cause misinterpretation of fractures. However, patient discomfort may make this impossible in the context of trauma.

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Adult anatomy

Three joints (humeroulnar, humeroradial and superior radioulnar) comprise a single synovial cavity. The distal humerus consists of the grooved trochlea and the rounded capitellum, which articulate with the ulna and radius respectively. The ulnar, radial and annular ligaments support the joint, with the latter supporting the superior radioulnar joint. The annular ligament attaches only to the ulna and allows the radius to freely rotate beneath it. Two depressions within the distal humerus are the coronoid (anterior) and olecranon (posterior) fossae.

Developmental anatomy

In the developing elbow, knowledge of the complex normal sequence of ossification of the epiphyseal growth plates is important (*Table 1*). The capitellum appears first at about 2 years of age, followed by the radial head, then the internal epicondyle. An avulsed internal epicondyle can resemble the normal trochlea, but this is easily identified as the trochlea ossifies after the internal epicondyle. The olecranon and lateral epicondyle ossify last.

Systematic radiological assessment

The patient's name, date of birth and date on the film should always be checked.

Film quality: As stated, optimal positioning is essential, particularly on the lateral film, as it is the most important view. The trochlea and capitellum should be superimposed, with the radius projected above the ulna. Superficial soft tissue fat and muscle planes should be visible.

Table 1. Average age of appearance of secondary ossification centres

Centre	Age of appearance
Capitellum	1 year
Radial head	3 years
Internal epicondyle	5 years
Trochlea	9–11 years
Olecranon	9–11 years
Lateral epicondyle	9–11 years

Bony alignment: On the lateral view, the anterior humeral line should intersect the capitellum between its middle and anterior third (*Figure 1*). The central radial line (radiocapitellar line) should intersect the middle of the capitellum. The coronoid process of the ulna and the radial head should be superimposed. On the AP view, the radius should be continuous with the capitellum and the ulna with the trochlea (*Figure 2*).

Bony density and margins: The cortical surfaces of all the visible bones should be systematically examined for irregularities. The internal trabecular pattern should be carefully assessed for subtle radiolucencies or bands of sclerosis, which may be the appearance of an impacted fracture. This is a particular difficulty with injuries to the radial head and neck, as approximately half of the fractures in this area are undisplaced. Like anywhere else the cortices

Figure 1. Normal lateral elbow radiograph. The anterior humeral line (green line) intersects the capitellum between its middle and anterior third. The central radial line intersects the middle of the capitellum (red line). The coronoid process of the ulna and the radial head are superimposed.

Figure 2. Normal anteroposterior elbow radiograph, showing the radius to be continuous with the capitellum and the ulna with the trochlea.

Figure 3. A displaced anterior fat pad is seen as a triangular lucency, raised anteriorly to the humerus (arrow). It is indicative of intra-articular fluid, which includes blood in the setting of acute trauma. As is often the case, the anterior fat pad may be visualized normally, although clinical suspicion should remain high.

common in children (*Figure 5*). They tend to vary widely, but are commonly caused by a fall onto an outstretched arm, and it is mandatory to assess the neurovascular status of the limb. If an angular force is applied, an epicondyle fracture may occur (*Figure 6*). Transcondylar fractures imply a significant force, but may occur in osteoporotic bones. Fractures of the capitellum are uncommon, but can be difficult to diagnose on plain radiographs. They usually result from valgus impaction forces.

Radial head fractures

Radial head and neck fractures are the commonest adult injury, accounting for over 30% of all elbow fractures. Typically caused by a fall on an outstretched hand, radial head fractures are usually orientated vertically, but radial neck fractures tend to be impacted and slightly angulated (*Figure 7*).

Figure 4. A positive posterior fat pad is invariably only seen with a fracture (black arrow). In this case, a subtle radial head fracture extending to the articular surface is visualized (white arrow).

Figure 5. A lateral elbow radiograph showing a displaced distal humeral fracture in an adult.

Cortical breaks can be difficult to visualize, with sometimes only a slight irregularity the only clue. Positive fat pad signs are often far more evident, and should be considered significant in the appropriate clinical situation even if the radial head fracture is not visualized. Oblique views are sometimes of use in showing these fractures.

Figure 6. An undisplaced lateral epicondyle fracture (black arrow) is shown with positive anterior and posterior fat pad signs (white arrows).

Adult trauma

Distal humeral fractures

Injuries to the distal humerus can be intra- or extra-articular, although are much more

Figure 7. An anteroposterior elbow radiograph showing a slightly displaced linear radial head fracture (black arrow).

Elbow dislocations

Dislocations of the elbow are uncommon and usually the result of valgus impaction, but almost invariably involve posterior dislocation of the radius and ulna with respect to the humerus. Fractures are frequently associated, most commonly the ulnar coronoid process, but also the internal epicondyle and radial head. They can be missed initially in the context of a potentially neurovascular threatening dislocation, but should be identified on the post reduction radiographs, as they can act as intra-articular loose bodies and lead to incomplete reduction and late onset arthritis (*Figure 8*). Isolated radial head dislocations are rare in adults, and a complete examination of the ulna must be made for associated injuries. They may manifest as just an abnormal central radial line (*Figure 9*).

Olecranon fractures

Olecranon fractures account for approximately 20% of adult elbow injuries, and result from either a direct blow or an avulsion injury related to contraction of the triceps muscle. The transverse fracture line usually passes into the trochlear notch, but most commonly the fracture fragments are distracted as a result of muscular contraction (*Figure 10*).

Figure 8. A lateral elbow radiograph showing a complete posterior elbow dislocation. Note is also made of a subtle avulsed bony fragment which is lying within the joint (black arrow), which can lead to incomplete reduction and late onset arthritis.

Proximal forearm fractures

Usually forearm fractures involve both bones, or a single fracture and a joint disruption, although isolated injuries can occur. A midshaft ulna fracture results from a direct blow from a heavy object (termed nightstick injury, following a blow from a policeman's baton) (*Figure 11*). Two rare fracture-dislocation patterns are recognized in the forearm, both usually resulting from a fall onto an outstretched hand with a flexed arm. The Monteggia injury is characterized by an anteriorly angulated fracture of the proximal third of the ulna associated with an anterior dislocation of the radial head. The Galleazi injury is characterized by a dorsally angulated distal radial fracture in conjunction with dorsal dislocation of the distal ulna. Occasionally the proximal radius and ulna may both be fractured, often in conjunction with an elbow dislocation in the context of severe trauma.

Figure 10. A lateral elbow radiograph showing an olecranon fracture. The fracture fragments are distracted as a result of muscular contraction. Note the absence of displaced fat pads, because of the capsular rupture.

Figure 9. A lateral elbow radiograph showing an isolated radial head dislocation. The central radial line (radiocapitellar line) is displaced and is the only sign of this subtle injury (white line).

Figure 11. Forearm radiographs showing an isolated midshaft ulna fracture. This resulted from a direct blow from a heavy object (black arrows).

Child trauma

Many of the injuries described above may also occur in children, but specific paediatric trauma will now be discussed.

Supracondylar fractures

Supracondylar fractures are the commonest fractures in children, making up 60% of all elbow fractures in this age group, and are usually caused by a fall on an outstretched hand. Usually a transverse fracture passes just proximal to the capitellum and trochlea, with the distal fragment often posteriorly displaced. The anterior humeral line passes through the anterior third of the capitellum or even completely anterior to it (*Figure 12*). Severely displaced fractures may cause neurovascular compromise, and early reduction is key (*Figure 13*). Undisplaced fractures are often missed, but a positive posterior fat pad sign is almost always present.

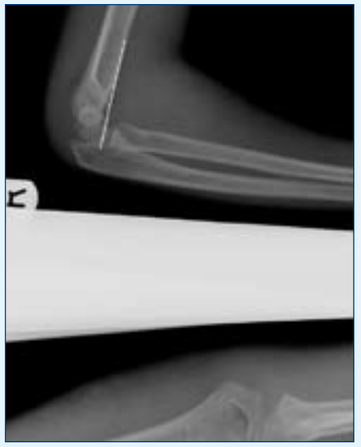

Figure 12. Anteroposterior and lateral radiographs show a transverse fracture of the distal humerus that passes just proximally to the capitellum and trochlea, and into the lateral epicondyle, with the distal fragment posteriorly displaced (black arrow). The anterior humeral line passes through the anterior cortex of the capitellum (line).

Figure 13. A lateral elbow radiograph showing a severely displaced supracondylar fracture, with the anterior humeral line passing completely anteriorly to the capitellum. With severely displaced injuries such as this, neurovascular compromise may occur.

Epicondylar injuries

Epicondyle injuries are the second commonest elbow fracture in childhood, with the lateral epicondylar fracture making up 15% of elbow fractures. They can be extensive, involving also the capitellum, trochlea and distal humeral metaphysis (*Figure 12*). This is not always appreciated if only the capitellum is ossified. Internal epicondylar epiphyseal avulsions occur in relation to elbow dislocations, and also in isolation caused by valgus stress (*Figure 14*). The avulsed epiphysis is usually displaced inferiorly, but it may pass intra-articularly. In this situation it may be misinterpreted as being one of the other ossification centres. Remembering the normal sequence of ossification will assist diagnosis (*Table 1*), as if the trochlear epiphysis is present, the internal epicondyle epiphysis must also be present, and may be avulsed and not immediately obvious. Positive fat pad signs may help, and in difficult cases a radiograph of the uninjured side may be of use.

Figure 14. An anteroposterior elbow radiograph showing an internal epicondylar epiphyseal avulsion. The avulsed epiphysis is displaced inferiorly (black arrow), and occurred as a result of sudden valgus stress.

Pulled elbow

Pulled elbow occurs in children between 1 and 4 years of age, and occurs when there is a sudden pull on the pronated extended arm, such as when the child is suddenly lifted by the hand. It occurs as a result of momentary distraction of the radiocapitellar joint, allowing subluxation of the radial head out of the angular ligament. Radiographs are usually normal (*Table 2*). BJHM

Conflict of interest: none.

Table 2. Common errors

Recognize that a visible anterior fat pad is normal, but if displaced there is a high chance of a fracture, often a subtle radial head fracture
Absence of a fat pad does not exclude a fracture
A radial head dislocation may just appear as an abnormal central radial line
A supracondylar fracture may just appear as an abnormal anterior humeral line
Fractures of the developing epicondyles can be mistaken for radiolucent epiphyseal lines
Entrapment of the avulsed internal epicondyle epiphysis can be mistaken for the trochlear epiphysis

KEY POINTS

- Always check the name, age and date.
- Assess film quality.
- Assess alignment, particularly anterior humeral and central radial lines on the lateral radiograph.
- Assess bony cortices for subtle fractures.
- Assess soft tissues for positive fat pad signs.

Further reading

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