Forearm fractures in adults

Niyati Jain
Hari Iyer
Sukhdeep Gill

Abstract

Forearm fractures are seen by the orthopaedic team either in the emergency department or in the fracture clinic. Injuries which include the more proximal or distal joints are rare but can lead to disabling consequences if missed. In this article we discuss the anatomy, classifications systems and management of these less common upper limb fractures.

Keywords Fracture; radius; ulna

The term forearm was used in anatomy to distinguish it from the arm, a word which is used to describe the entire appendage of the upper limb, however in anatomy it only meant the region of upper arm. Lower 'arm' is now called the forearm, which is the area between the elbow and the wrist joint. It is homologous to the region of the leg that lies between the knee and the ankle joints. The earliest known use of the noun 'forearm' was in the mid 1700s as noted by the Oxford English Dictionary's earliest evidence from 1739, in a translation by John Sparrow.[1]

Forearm fractures involve fractures of the shafts of the radius and the ulna and at or around the elbow and wrist joints. Caused mainly by trauma, they are a common presentation in orthopaedics and are managed either conservatively or surgically.

Anatomy

The forearm is made up of two bones: the radius and the ulna. In the anatomic position (palm facing upwards and elbow completely extended) the radius is present on the lateral (outer) aspect of the forearm. It articulates with the capitellum of the humerus to form the humeroradial joint at its proximal end and with the carpal bones distally to form the wrist joint.

On the medial (inner) aspect of the forearm lies the ulna: the longer and straighter of the two bones. It forms the humeroulnar joint at the elbow by articulating with the trochlea of the humerus at its proximal end. At the distal end it has the styloid process (felt as a bony bump on the wrist joint), which has the attachment to the triangular fibrocartilaginous complex (TFCC).

Niyati Jain ***MBBS*** *is a Trauma and Orthopaedic Resident Doctor at Portsmouth Hospital University NHS Trust, Portsmouth, UK. Conflicts of interest: none declared.*

Hari Iyer ***MBBS*** *is a Trauma and Orthopaedic Resident Doctor at Portsmouth Hospital University NHS Trust, Portsmouth, UK. Conflicts of interest: none declared.*

Sukhdeep Gill ***MBBCh FRCSEng (Tr&Orth)*** *is a Trauma and Orthopaedic Consultant at Portsmouth Hospital University NHS Trust, Portsmouth, UK. Conflicts of interest: none declared.*

The two bones articulate upon themselves to form the proximal and distal radioulnar joints.[2,3] The axis of rotation of forearm runs through the radial head at the proximal aspect and ulna fovea at the distal end. During pronation and supination the bowed radius rotates around the straight ulna. In the coronal plane the maximal radial bow is about 15 mm at 60% distally along the radius. A slight bow is seen in the ulna along the distal 75% of the shaft.[4–7] The shafts of the two bones are connected by the interosseous membrane, which provides 75% of the stability of the forearm.

The elbow is a modified hinge joint which helps in a wide range of movements of the forearm. Forearm flexion is a rotation in the anatomic plane such that the radius and ulna move anteriorly. It primarily occurs at the articulation between the humerus and ulna and can achieve approximately 150° of movement in most individuals.[6]

The forearm also consists of muscles of the wrist and digits along with nerves and blood vessels supplying them, thus any fracture of the long bones can affect these vital structures around them.

Aetiology

The aetiology of forearm fractures is quite variable, ranging from high energy trauma to a simple fall. Of the most common causes for forearm fractures is a direct blow to the forearm which could lead to a single fracture of radius, ulna or both. Another common cause is fall onto an outstretched hand, which causes axial loading on the forearm.[8]

Some other indirect causes of trauma to forearm include sport injuries and road traffic accidents.[7]

Fractures in the forearm could also be involved in severely debilitating injuries, such as those seen from farmyard and industrial machinery. In such cases, where severely mangled extremities are involved, the management poses great challenges, where the decision to salvage the limb is made.

Less common causes include gunshot wounds, which could involve the bones in the forearm causing a fracture.

Deforming forces

The deforming forces in a forearm fracture depend on the level of the fracture. In proximal third fractures, the proximal fragment is flexed and supinated by biceps and supinator whilst the distal fragment is pronated by pronator teres and quadratus. In a distal third fracture, brachioradialis dorsiflexes and radially deviates the distal fragment. With middle third fractures, the interosseous membrane holds the proximal fragment in neutral whilst the distal fragment is pronated by pronator teres and quadratus.

Epidemiology

Although more common in the paediatric age group, forearm fractures are also noted to occur in adults. Distal radius or ulna fractures are the most frequently occurring fractures in the forearm, and the least common location is the proximal region. Open fractures, on the other hand, most commonly involve the diaphyseal region.

Based on the data collected in an abstract published in NIH in 2001, it is estimated that 71,000 adult men and women sustain a distal forearm fracture in Britain each year.[9]

A gender bias is also seen in distal radius fractures, with the fracture more common in males compared to females below age 35 years, but over this age they become more frequent in women, as do the other fractures that have been associated with osteoporosis.[10,11]

A comprehensive analysis done by McQueen et al. in the trauma unit of the Royal Infirmary of Edinburgh over a period of 3 years analysed the incidence of forearm fractures seen during this period. This unit catered exclusively to adult trauma cases in a specified area and population and thus was a very good guide to the epidemiology of forearm fractures in a westernised country.[12] In this analysis, of the 2812 fractures, just 5% were diaphyseal forearm fractures, and an overwhelming majority (76%) were distal radius fractures.[12]

A study done in the US that looked at the epidemiology of forearm fractures in the patients coming to the emergency department across 66 out of 100 National Electronic Injury Surveillance System (NEISS) hospitals showed a significant gender difference among adults aged 50 years or more presenting with unintentional falls.[13]

Classification

The most practical and simplest classifications include[14]:

Based on bone involvement:

- radius
- ulna
- radius and ulna

Based on location of the fracture:

- distal third
- middle third
- proximal third

There is no one way to classify forearm fractures, however the OTA classification system attempts to simplify this on the basis of fracture types: A (Simple), B (Wedge), C (Complex); and involved bones: 1 (Ulna), 2 (Radius), 3 (Both bones).

Involvement of the joint above or below

If only one bone is fractured, there is usually instability of the proximal or distal radioulnar joints.

Monteggia's fracture: in 1814 Giovanni Battista Monteggia described the fracture of the proximal one third of the ulna associated with radial head dislocation. Till this date, these types of fractures remain difficult to diagnose clinically resulting in serious complications if not treated adequately.[15] The Bado classification is used to classify Monteggia fracture dislocations based on the type of radial head dislocation:

- Type 1 — Ulna fracture and anterior dislocation of the radial head
- Type 2 — Ulna fracture and posterior dislocation of the radial head
- Type 3 — Ulna fracture and lateral dislocation of the radial head
- Type 4 — Ulna and radius fracture and dislocation of the radial head in any direction

Galeazzi fracture: commonly seen in the paediatric population, it was first described by Sir Astley Cooper in 1822, but the eponym only took hold in 1934, when the mechanism of injury was described by Riccardo Galeazzi. It is a distal one third radius fracture with associated radioulnar joint dislocation or subluxation. It accounts for 7% of all the forearm fracture in adults.[16,17]

Nightstick fracture: Well recognized but rather rare, isolated ulnar shaft fracture is known as 'nightstick' fracture, since this type of fracture was suspected to occur when a person held their forearm in front of their face to avoid a police baton injury. Higher chances of nonunion are a known complication of this type of fracture, thus requiring timely and regular follow-ups.[18]

Esses Lopresti fracture: named after Peter Essex-Lopresti, it is a high velocity fracture involving compressive forces leading to a radial head fracture with dislocation of the distal radioulnar joint (DRUJ) with disruption of the interosseous membrane.[11,19,20] Less than 20% of this type of fracture-dislocations are diagnosed at time of initial presentation, with a significant number of patients having unremarkable initial radiographs. An interesting study done involving 20 patients ranging in age from 8 to 74 years and followed up for a period between 4 months and 27 years demonstrated that in 15 patients, the injury of the wrist was diagnosed after a mean delay of 7 years and 11 months, which resulted in significant crippling complications to the patients.[21]

Presentation and assessment

Just like any fracture, forearm fractures present with pain, swelling, deformity and limitation of movement of the hand or forearm depending on the site of the injury. A detailed history on the nature of injury along with past medical and social history aids in making management plans that are patient centric. Hand dominance is yet another aspect to know as forearm fractures can reduce baseline functionality in older and frail adults.

The classic 'look, feel, move' approach in clinical examination gives a good idea of the site and nature of the fracture.[22] It is important to note the skin integrity of the fractured limb to rule out an open fracture. Once the site is determined, joint stability above and below the fracture must be evaluated. The examination must also include examining the function of the median, ulnar and radial nerves and the vascular integrity distal to the fracture, as well as evaluating the forearm compartments to rule out compartment syndrome.

Investigations

The most commonly performed investigation for any forearm fracture is a plain radiograph done in preferably both anteroposterior as well as lateral views. The radiographs can show the degree of displacement and extent of communition. They are also helpful in finding any potential foreign body that could be present in open fractures.

A standard radiographic projection done for the anteroposterior view is performed with the elbow in extension and forearm fully supinated.

As a general safe practice, it is always recommended to get plain radiographs for a joint above and a joint below to ensure no secondary fracture is present. Hence the elbow and wrist joint should be included in images for completeness of the evaluation.

If there are any concerns about the joint, a true AP and lateral of the wrist and/or the elbow should be obtained to rule out any joint dislocation.

Lateral views of the forearm can lead to overlapping of bones and in such cases oblique views are done to get a better look at the fracture pattern.

Recently the development of AI technology has been used to identify upper extremity fractures on radiographs and as per an article published in 2023, AI technology has shown high accuracy.[23]

Computed tomography (CT) may be useful in distal radial fractures and radioulnar joint pathologies. This is particularly useful in cases where there is suspicion of intra-articular pattern of distal radius fracture. It can also be done in cases where it is difficult to rule out the extent of the fracture on a plain radiograph.[24]

It is not routine practice to get magnetic resonance imaging (MRI) scans for uncomplicated forearm fractures, however it can be useful to diagnose DRUJ injury with TFCC injury. When injury to vessels is suspected, it is important to get angiography or vascular Doppler ultrasonography (US).[25]

Management

The initial management of fractures starts with analgesia. Early and adequate pain relief aids in good patient assessment and easier fracture reduction, thereby providing better outcomes in patients.[26] NICE recommends the following pharmacological management for patients over the age of 16:

- Oral paracetamol for mild pain
- Oral paracetamol with codeine for moderate pain
- IV paracetamol with titrated IV morphine for severe pain.

NSAIDs are to be used with caution in frail and older adults. Known for their properties to inhibit osteogenesis, a meta-analysis done in 2019 showed that NSAID exposure increased delayed union or non-union of fractures, however no effect was noted in paediatrics or low dose/short duration of exposure.[27]

Immediate application of a back slab is not only effective in temporary stabilization of the fracture but also provides adequate pain relief. While an above elbow slab is applied for proximal radial or ulnar fractures or both radial and ulnar shaft fractures, a below elbow back slab is used for distal forearm fractures. Back slabs are only temporary fixes until definitive management — a full cast or surgical fixation of the fracture.[28]

Effective reduction in anatomical position in the emergency department or theatre is key. The manipulation of the fracture is mostly done while putting the back slab on. It helps in restoring the anatomy of the broken bone and prevents damage to the nerves and vasculature. Simple isolated ulnar shaft fractures often only require a good manipulation and can be treated conservatively. However, most forearm fractures eventually need definitive surgical management.[29]

The need for surgical management is a decision taken by the operating surgeon based on patient demographics and the fracture pattern. Fracture dislocations like Monteggia and Galeazzi or distal radius fractures generally need surgical intervention. An open fracture or gross neurovascular compromise are indications for urgent surgery.

The aim of surgical treatment is to restore length, rotational stability and maintenance of radial bow whilst ensuring the proximal and distal radioulnar joints are fully reduced, to allow flexion and extension of the wrist and elbow, as well as supination and pronation of the forearm.[30] Open reduction and internal fixation (ORIF) are done either with screws and plates or rods.[31]

A Thompson approach is used to access the proximal two thirds of the radius. It is also known as the dorsal or anterolateral approach and was first described by Thompson in 1918, utilizing the plane between extensor carpi radialis brevis (ECRB) and extensor digitorum communis (EDC).

The distal two thirds of the radius is accessed by the volar or anterior approach. This incision was originally described by Henry in 1927, utilizing a plane between brachioradialis and flexor carpi radialis (FCR). Boyd described an approach to the proximal radius using the plane between flexor digitorum profundus (FDP) and extensor carpi ulnaris (ECU), which is useful in Monteggia and radial head fractures.

The ulnar approach is more straightforward, with a longitudinal incision taken along the subcutaneous border of the ulna, going between the flexor carpi ulnaris (FCU) and ECU. Be aware that the FCU/ECU border may cross over the border of the bone and you must take care to ensure you remain between the two muscles.

Open reduction and internal fixation can be obtained using a plate in a variety of modes of fixation. Dynamic compression plates are widely used to reduce transverse ulnar and radial shaft fractures, compressing the fracture. A lag screw through a plate or separately is used to achieve interfragmentary compression in oblique types of fractures. Bridge plating can be used when there is a comminuted fracture, ensuring that the overall alignment of the radius and ulna are achieved in this instance to prevent loss of supination/pronation. In the majority of adults, conventional screws can be used but in poor quality bone the additional purchase obtained from locking screws in a locking plate construct is useful. External fixation is used as a temporary measure to provide some stability in cases of bone loss and severe soft tissue damage prior to definitive fixation.

In the Monteggia type of fracture dislocation, the ulnar shaft fracture must be fixed first and then the radial head reduced. Open reduction of the radial head is required in approximately 10% of cases when there is soft tissue interposition interfering with closed reduction. Bado type 4 injuries require open reduction internal fixation of the radial head fracture, or excision of the fragments if there are no concerns about radiocapitellum stability. If the radial head cannot be reconstructed in cases of instability, the radial head will require replacement.

Similarly, in the Galeazzi type of fracture, adequate radial reduction and fixation leads to spontaneous ulnar head reduction and a stable DRUJ through a full range of pronation and supination. If following reduction of the radius the DRUJ remains unstable, further treatment options to stabilize the DRUJ are required, which can be temporary or permanent.

When both radius and ulna are broken, preliminary fixation of the simpler fracture is done first followed by definitive fixation of the other bone. If both bones have a similar fracture type, then the ulna undergoes preliminary fixation.

Closed reduction and intramedullary (IM) nail fixation can also be performed. Ulnar nail is inserted through the posterior olecranon while the radial nail is inserted between the extensor tendons near the Lister tubercle. A meta-analysis of cohort studies of fractures fixed with ORIF and IM nailing done in 2017 noted that IM nailing had lower operation time and complications as compared to ORIF.[32] However there is not enough anatomic stability for this type of fixation to be used in adults and therefore this is only used in children.

When treating an Essex-Lopresti injury, it is important to reconstruct/replace the radial head and stabilize the DRUJ to ensure the interosseous membrane is adequately reduced. Later reconstruction of the interosseous membrane may be required if this is not the case.[11]

Complications

The most important and severe of the complications is acute compartment syndrome (ACS). It usually presents as a painful swollen limb with neurovascular compromise. If left untreated it could cause disastrous and debilitating outcomes for patients. A study done in 2023 to identify the risk factors of ACS in both forearm fractures shows that a crush type of injury, neutrophils and CK are significant risk factors causing ACS in patients with both bone forearm fractures.[33] Urgent fasciotomy to relieve compartmental pressure is the management.

Delayed complications can include malunion of bone and non-union of the bone, which can cause restriction in movement needed for activities of daily living. Other potential complications include acute or delayed onset nerve damage. PIN palsy is seen with proximal forearm fractures while median nerve palsy causing CTS is seen with distal radius fractures. ◆

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Practice points

- Be aware of any involvement of the proximal and distal radioulnar joints
- The aim of treatment is to restore length, rotational stability and maintenance of radial bow whilst ensuring the proximal and distal radioulnar joints are fully reduced

