SUMMARY

Fractures of the elbow comprise 5% of fractures. Most are minimally displaced and can be managed conservatively. Displaced fractures or those associated with elbow dislocation are likely to require operative intervention. Displaced distal humeral fractures present a particular clinical challenge. Elbow stiffness is the most common complication and can follow seemingly innocuous/minimally displaced fractures.

INTRODUCTION

The management of fractures around the elbow can be challenging due to the complex anatomy and biomechanics of the joint. Consequent incongruity of the articular surface can lead to loss of range of movement and function. This article gives an overview of the management of such fractures, taking account of joint anatomy and biomechanics, their epidemiology and classification.

CLINICAL ANATOMY AND BIOMECHANICS

The elbow is a hinge joint between the humerus proximally and the ulna distally, while a further articulation between the humerus and radius allows rotation of the forearm around the ulna around a single axis. The distal humerus is described as comprising lateral and medial columns separated by the trochlea lying in 4–8 degrees of valgus and 3–8 degrees of external rotation with respect to the longitudinal axis of the humerus. The distal articular surface is angulated anteriorly by 30 degrees in the lateral plane projecting further distally on its medial aspect (Fig. 1). Articular cartilage covers the trochlea for almost 300 degrees of its circumference, which is divided into medial and lateral portions by a groove running from antero-lateral to posteromedial. This articulates with a ridge on the trochlea notch of the proximal ulna (Fig. 2). The two parts of the trochlea notch, the coronoid anteriorly and the olecranon posteriorly are, in most patients, separated by an area bare of articular cartilage, usually occupied by fatty tissue. Therefore undisplaced fractures through this area may have little effect on elbow function. Similarly, osteotomies can be undertaken through this area without damaging the articular surface.

The trochlear notch is angled approximately 1–6 degrees laterally and by about 30 degrees posteriorly to the ulna shaft. The latter confers stability on the elbow joint by matching the anterior orientation of the distal humerus,
giving maximum stability in full extension when the coronoid forms a large buttress due to its angulation. The capitellum is hemispherical and articulates with the concavity of the radial head which is covered with articular cartilage. Additionally about 240 degrees of the outer circumference of the radial head is covered with articular cartilage, where it articulates with the ulna forming the proximal radio-ulnar joint. The remaining antero-lateral 1/3rd of the outer circumference is an area prone to fracture because it lacks subchondral bone. However, being bare of articular cartilage makes it suitable for the application of a plate. The radial neck is narrower than the head and both are at an angle of approximately 15 degrees to the longitudinal axis of the radial shaft (Fig. 3). While the radial head shares the axial load forces across the elbow joint, it also reduces forces acting on the medial collateral ligament during valgus loading. It also prevents proximal migration of the radius in relation to the ulna.

The valgus carrying angle of the elbow in extension is due to the distal articular surface projecting further distally on its medial aspect, the groove in the distal articular surface running anterolaterally to posteromedially and the trochlear notch being angulated approximately 1–6 degrees laterally to the ulnar shaft (Fig. 4). The angle can be lost in fracture malunion, particularly seen in paediatric supracondylar fractures, necessitating corrective osteotomy.

The two epicondyles and the tip of the olecranon lie in a straight line in extension and a roughly equilateral triangle in 90 degrees of flexion. This latter can be useful in the clinical assessment of elbow fractures or dislocations (Fig. 5). The medial epicondyle is the more prominent and is part of the origin of the flexor/pronator group, whereas the lateral epicondyle is that of the extensor and supinator group.

Stability of the elbow

The epicondyles are also the origin of the collateral ligaments, which, with the bony articulation of distal humerus and trochlea notch, are the main static stabilisers of the elbow. Dynamic stabilisers include the muscles and tendons crossing the joint, i.e. brachialis and the flexor pronator group, and to a lesser extent triceps and the extensor supinator group.

The collaterals are important in bony injury. The medial collateral ligament comprises an anterior, posterior and oblique portion. The anterior band is the most important and attaches to the anterolateral margin of the coronoid – the sublime tubercle. Also attaching to the coronoid is the anterior capsule and brachialis. The parts of the lateral collateral ligament (LCL) are less well defined. They include the radial LCL which blends with the annular ligament which is the main stabiliser of the radial head. The ulnar LCL also blends with the annular ligament, but has
fibres which pass superficially to the annular ligament and insert on to the supinator crest of the ulna and coronoid. It is the latter ulna LCL which is functionally most important and is implicated in chronic posterolateral instability (Fig. 6).

The main restraint to varus stress is the ulna humeral articulation which provides 55% of the overall restriction at full extension and 75% at 90 degrees of flexion. The main restraint to valgus stress is the anterior band of the medial collateral ligament which provides up to 50% of the restraint. A further 30% is provided by the radial head with the remainder being provided by other capsuloligamentous structures. The elbow is prevented from hyperextending by impaction of the olecranon into its fossa, tightness of the anterior capsule and the anterior flexor muscles. Similarly, hyperflexion is prevented by impaction of the tip of the coronoid into its fossa, the radial head into the fossa above the capitellum and the posterior musculature, particularly triceps. (Fig. 7).

Fracture epidemiology and aetiology

Fractures around the elbow account for 5% of all fractures and are more commonly seen in older females and young males, but each individual fracture pattern has its own age and gender distribution. Most fractures are of the proximal ulna and radius; distal humeral fractures account for only 0.5% of all fractures. The most common fracture is of the radial head, comprising 56% of all fractures of the proximal forearm. This is followed by fractures involving the olecranon and radial neck, 20% each, with fractures involving both radius and ulna accounting for only 4% of all fractures involving the proximal forearm.

The majority of patients sustain their fracture following a fall from standing height (>60%) or sports injuries (>15%). Very few patients sustain their injuries due to high energy trauma such as motor vehicle accidents or gunshot wounds and more than 99% are closed injuries.

Radial head and neck fractures

In many cases the only evidence of a fracture of the radial head or neck is haemarthrosis visible on a lateral x-ray of the elbow (Fig. 8). Dedicated radio capitellar views (Fig. 9), may identify minimally displaced fractures. If the fracture is part of a complex injury or there is severe comminution then computed tomography (CT) will give additional important information (Fig. 10).
The earliest classification of radial head fractures was by Mason in 1954:

- undisplaced,
- displaced
- comminuted fractures involving the whole head.

Broberg and Morrey\(^4\) modified Mason’s classification (Fig. 11):

- type 1 < 2 mm displacement
- type 2 > 2 mm of displacement and >30% involvement of the head
- type 3 comminution involving the whole head.

- Type 4 radial head fracture associated with an elbow dislocation

Hotchkiss further modified this according to the range of movement possible at the elbow.\(^5\) Type 1 has no mechanical block to movement and any restriction is due to pain and/or haemarthrosis, Type 2 has a mechanical block despite aspiration of haemarthrosis and Type 3 has a mechanical block necessitating excision of the radial head to restore movement i.e. the radial head is not reconstructable and must be replaced. It follows that aspiration of the radiocapitellar joint and infiltration of local anaesthetic can be a useful adjunct to management of pain relief due to the injury as well as providing information with regard to management.

Figure 6  The collateral ligaments of the elbow.
The importance of the radial head in providing stability to the elbow joint has already been mentioned. It is not surprising that clinical studies comparing fixation to simple excision are in favour of internal fixation. While Mason type 1 fractures in isolation can be treated conservatively with no significant long term sequelae, most authors agree that an attempt at fixation should be made with Mason type 2 fractures, but also agree that results are variable with high rates of fixation failure, non union and secondary procedures. Jupiter and Ring suggest that Mason type 2 fractures have a better outcome if there was a single large marginal fragment and no comminution, and there are better outcomes in Mason type 3 fractures if there are 3 or fewer fragments. In their retrospective study, concomitant injury such as elbow dislocation, posterior Monteggia fracture or Essex Lopresti lesion were a poor prognostic factors in Mason type 2 fractures but made little difference to the overall result in Type 3 fractures.

**Surgical treatment**

A Kocher approach utilising the interval between extensor carpi ulnaris (posterior interosseous nerve-PIN) and anconeus (radial nerve) will give adequate exposure in most cases. The approach is made safer by forearm pronation which moves the PIN further from the surgical field. As the annular ligament is the principal stabiliser of the radial head, it must be repaired or reconstructed. A large variety of implants are available to allow adequate fixation including fixed angle devices, congruent plating systems, headless cancellous screws and wiring systems. Any plate

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*Figure 7*  The bony anatomy prevents hyper flexion and hyper extension in combination with the soft tissue stabilisers.
used should be applied to the bare area of the radial head as described above to minimise the risk of restricting supination and pronation. Any screws or wires used should be buried beneath the chondral surface for the same reason. Early mobilisation is the key to avoiding stiffness and can only be achieved with stability of internal fixation.

There is continuing controversy as to whether to internally fix the radial head or to replace it with a prosthesis. While preservation of the radial head provides more normal biomechanics around the elbow with restoration of bone stock, replacement of the radial head avoids the problems associated with metalwork failure and non union. A metal prosthesis is superior to silastic providing a closer biomechanical match to the native radial head and avoids problems arising from fragmentation and associated synovitis. The main concerns are achieving correct balance, avoiding instability or ‘overstuffing’ of the joint; an undersized prosthesis may cause valgus instability and pain, too large a prosthesis causes pain and early degenerative changes in the radiocapitellar and ulnohumeral articulations. The underlying cause of incorrect sizing is thought to be related to the lack of modularity of prostheses and several authors have proposed modular systems to more effectively recreate the shape and offset of the natural radial head. However, no difference has been demonstrated between the modular and standard variants of radial head prostheses, and overstuffing still occurs. Review of the literature suggests that internal fixation should be attempted, but in the presence of comminution then primary radial head replacement is an acceptable alternative.

Authors’ preferred technique

Our practice is to adequately visualise any injury with additional radiocapitellar views if there is haemarthrosis and no obvious fracture. The elbow is aspirated and local anaesthetic injected aseptically allowing an examination under anaesthesia. If no block to movement exists then the fracture can be safely treated with early active mobilisation with analgesia and ice packs as adjuncts. Displaced fractures causing a block to motion are either fixed or excised if not reconstructable. Comminuted fractures are managed with a titanium radial head replacement.

Practice points—radial head and neck fractures

- History and examination—other injuries around elbow, wrist, forearm
- AP, Lateral and Radio capitellar radiographs—haemarthrosis, complex injury pattern
- CT Scan—complex injury pattern, comminution
- Aspirate haemarthrosis, inject local anaesthetic and EUA
- No mechanical block—conservative treatment
- Mechanical block—consider fixation, excision or prosthetic replacement

Olecranon fractures

Olecranon fractures are more common in the elderly and are usually caused by a fall onto a semi-flexed and supinated forearm or by a direct blow on to the point of the olecranon. Very occasionally the fracture results from an avulsion of the triceps insertion.

The AO classification describes olecranon fractures as segment 21 — with A being extra-articular, B partial and C intra articular. The Colton classification is:

- Type A fractures are typically avulsion fractures which usually occur in the elderly,
- Type B are oblique fractures which may also be comminuted and can have a sagittal split,
Figure 10  CT reconstruction views can give additional information especially with commination.

Figure 11  Broberg and Morrey’s modification of the Mason classification of radial head and neck fracture. A full description is provided in the text.
Type C are those where there is a fracture dislocation and
Type D are unclassifiable, i.e. there is major comminution usually secondary to a high energy direct injury (Fig. 12).

Morrey proposed an alternative classification system to take into account stability, comminution and general patient factors to better guide management (Fig. 13).

Type 1 undisplaced and stable,
Type 2 displaced but the elbow remains stable whereas
Type 3 displaced and the forearm is unstable with respect to the distal humerus.

He added a sub-classification:

• type A un-comminuted
• type B comminuted

Undisplaced fractures at any age can be safely managed in plaster for a short period of time before commencing early active mobilisation. Displaced fractures in young patients or those with high functional demands usually require internal fixation. However, displaced fractures in patients with lower functional demands or those who are physically unfit can be adequately treated conservatively if they are able to demonstrate active elbow extension with gravity eliminated, and accepting that the incongruity of the articular surface may predispose to degenerative changes.

Fractures of the olecranon with a dislocation of the elbow require operative intervention and consideration of the overall injury to the elbow and repair of any other stabilising structures (see article on elbow instability).

The surgical approach is usually a dorsal approach to the subcutaneous border of the ulna with extension into the posterior approach to the distal humerus allowing identification of the triceps insertion and the proximal fragment which has usually retracted proximally. The skin incision should be offset from the midline to avoid a scar over the tip of the olecranon, and careful soft tissue handling is paramount in view of the local soft tissue contusion usually present. The authors recommend a curved incision towards the radial side to avoid injury to the ulnar nerve on the medial side.

The main determinant as to which method of fixation to use is the configuration of the fracture. Where there is no comminution and adequate opposition of both cortices is possible, then the tension band wire method as advocated by the AO group is the method of choice. There is a relatively high complication rate due to metalwork prominence

![Figure 12](image-url)  Colton Classification of olecranon fractures. A full description is given in the text.
and backing out of wires in this subcutaneous area. To reduce this, at the time of surgery, all wires should be buried appropriately so that they are not prominent once soft tissue swelling subsides. A modification of the intramedullary K wire technique is to ensure that the wires engage and pierce the opposite anterior cortex, as this has shown an overall improvement in the stability of the tension band. However, it is important that the distal ends do not penetrate the opposite cortex in the region of the proximal radio-ulnar joint as this will restrict forearm rotation. However, biomechanical analysis suggests that fixation by of a 7.3 mm cancellous screw rather than Kirschner wires (K wires) is better and other studies have shown that a 1/3rd tubular plate also gives better fixation. The use of plates in fractures where there is no comminution is becoming increasingly popular.

Figure 13  Morrey classification—takes into account the amount of displacement and comminution. A full description is provided in the text.
as they can provide superior fixation in osteoporotic bone especially with the use of newer contoured locking plates. IM nailing has also been reported as giving satisfactory results.28

If there is comminution or bone loss, tension band wiring is not appropriate as it can lead to shortening of the olecranon and incongruity of the articular surface.29 Internal fixation using 1/3rd tubular plates contoured to the ulna and olecranon combined with interfragmentary fixation of comminuted fragments (if possible) can give good results.30 Newer plating systems which provide congruent pre-moulded plates act as a template for reconstruction in cases of severe comminution and allow the use of locking screws to provide additional fixation.31 As with tension band wiring, attention should be given to the likely prominence of the fixation once soft tissue swelling has subsided.

When the olecranon is not reconstructable the option remains of excising the olecranon and advancing the triceps insertion into the proximal ulna. This may be particularly useful in open fractures or where there is significant soft tissue loss or damage. To minimise the mechanical disadvantage, triceps must be re-attached as close to the articular surface as possible.32

Authors’ preferred technique
Our preferred treatment depends on AP and lateral radiographs of the elbow and on the ability of the patient to actively extend the elbow with gravity eliminated. The only absolute indication for olecranon fixation is associated instability. Thus undisplaced fractures and displaced fractures in elderly patients with low functional demands who are able to actively extend the elbow are treated conservatively with regular follow up to ensure that this active extension is maintained and that there is no further displacement. Displaced fractures in young patients with high functional demands are generally treated operatively. Our preferred method of fixation in displaced fractures with no comminution is tension band wiring paying particular attention to engagement of the wires in the distal cortex so as to reduce the incidence of backing out (Fig. 14). In the presence of comminution our preferred method is internal fixation using a standard 1/3rd tubular plate or congruent locking plate if available.

Figure 14  A displaced olecranon fracture treated with tension band wiring.
Coronoid fractures

These are very rare in isolation and are more likely in the presence of an elbow dislocation; 10% of all elbow dislocations have an associated coronoid fracture. The first classification was by Regan and Morrey33 based on how much of the height of the coronoid was involved on a lateral radiograph (Fig. 15).

- type 1 involves only the tip,
- type 2 < 50% of the total height
- type 3 > 50% of the total height.

They subdivided each type into A and B, with or without elbow dislocation.

Although this classification correlates well with eventual outcome with a worse outcome seen in type 3 fractures33 it has been criticised for not taking into account the anatomical site of the fracture as this correlates with the type of injury to the elbow. Thus O'Driscoll proposed a new classification system34 according to the anatomic location of the fracture (Fig. 16).

Type 1 involve only the tip of the coronoid and usually have the entire capsular insertion attached to the fragment.35 These are usually associated with the so-called “terrible triad” of elbow dislocation, radial head fracture and coronoid fracture. The term was coined by Hotchkiss,36 and the injury also involves the soft tissues including the collateral ligaments. They require reconstruction of the coronoid height and the radial length by whatever means possible to allow elbow stability to be regained but there is a poor prognosis despite the best efforts at reconstruction.37

Type 2 fractures involve the anteromedial aspect of the coronoid i.e. the insertion of the anterior band of the MCL to its tubercle on the coronoid.

Type 3 fractures involve >50% of the coronoid height and may be associated with a concomitant olecranon fracture.

In general type 1 and 2 are associated with a great deal of soft tissue disruption whereas type 3 is usually associated with more bony damage; the capsular/ligamentous structures are usually intact as they are attached to large bony fragments. Therefore a relatively innocuous looking fracture of the coronoid such as a small antero-medial avulsion can be associated with a great deal of soft tissue damage and persistent instability of the MCL if this is not recognised.

Authors’ preferred technique

We treat these fractures depending on the pattern of dislocation encountered and involvement of other structures such as the radial head or collateral ligaments. If the elbow is stable, most coronoid fractures can be safely treated conservatively once other injuries such as repair of the collateral ligaments and fixation or replacement of the radial head have been addressed.

Distal humerus

These fractures are more common in elderly females with a very similar distribution to distal radial fractures. They frequently occur in osteoporotic bone and consequently can be extremely difficult to treat.2 Although most necessary information can be obtained from initial plain AP and lateral radiographs, CT can be useful to fully delineate the fracture configuration especially when there is articular involvement where fixation is planned (Fig. 17).

There are numerous available classification systems. They can classified as being extra-articular, intra-articular or exclusively articular where the fracture lines do not extend into the metaphyseal bone. The AO alphanumerical system describes these fractures as group 13—with type A being extra-articular, type B partial articular and type C intra-articular15 (Fig. 18).

Riseborough and Radin38 classified ‘T’ shaped fractures into 4 subtypes:

- Type 1 undisplaced
- Type 2 displaced without rotation
- Type 3 displaced and rotated
- Type 4 comminuted and grossly displaced.

Practice points-olecranon fractures

**History and examination**-functional demands, extension with gravity obliterated.
**Radiographs**-displacement, comminution.
**Conservative management**-regular surveillance and follow up.
**Surgical Management**-soft tissue handling, prominent metalwork

Practice points-coronoid fractures

**History and examination**-dislocation or isolated injury
**Radiographs**-displacement, dislocation, other injuries
**Conservative management**-isolated injury/stable elbow
**Surgical Management**-address other structures as well as coronoid
Jupiter and Mehne\textsuperscript{39} classify distal humeral fractures according to the configuration of the fracture and describe high and low "T" shaped, "Y" shaped, "H" shaped and lateral and medial "lambda" configurations (Fig. 19). These classification systems have been assessed for both intra and inter-observer reliability, but only moderate to fair agreement was found.\textsuperscript{40} A simpler classification system suggested by Davies and Stanley gives better intra and inter-observer agreement in their study.\textsuperscript{41}

Bryan and Morrey in 1985\textsuperscript{42} attempted to classify purely articular fractures, grouping capitellar fractures in terms of the shape and size of the capitellar fragment. Type 1 ("Hahn Steinitz") is a shear fracture with cancellous bone attached; type 2 ("Kocher-Lorenz") is a shear fracture but with only a thin layer of subchondral bone, essentially an osteochondral fragment (Fig. 20) and type 3 is a comminuted fracture. McKee\textsuperscript{43} added a type 4, a type 1 with extension into the trochlea, seen as a double crescent sign on a lateral radiograph (Fig. 21).

Ring and Jupiter\textsuperscript{44} further classified articular surface fractures into 5 types based upon the intraoperative findings and preoperative CT scan (Fig. 22).

- type 1 fracture involves the whole of the capitellum, extending into the lateral aspect of the trochlea
- type 2 extends into the lateral epicondyle
- type 3 has impaction of the metaphyseal bone posterior to the capitellum
- type 4 extends into the posterior aspect of the trochlea
- type 5 extends into the medial epicondyle.

Regardless of the classification system used, the principles of treatment are anatomic articular reduction, stable internal fixation of the articular segment to the metaphysis.

Surgical approaches and fixation
For extra-articular and partial articular fractures the approach of choice is the posterior approach utilizing either a triceps turn down (Fig. 23) or olecranon osteotomy (Fig. 24). There are concerns that the turn down may not give adequate exposure or that the osteotomy may lead to non union or metalwork prominence post-operatively and authors on either side of the argument provide data to support the use of their chosen approach.\textsuperscript{45,46} We feel it is important to be familiar with both approaches. A further area of controversy is whether or not to explore the ulnar nerve and formally transpose it anteriorly. Some authors feel it is mandatory to do so,\textsuperscript{47} others feel it is unnecessary.\textsuperscript{48} The advantage of transposition is that it provides exposure of the medial condyle and epicondyle allowing better reduction and fixation of the medial joint fragment.

Purely articular fractures can be approached using a Kocher approach between extensor carpi ulnaris and anconeus which can be extended along the lateral condylar ridge.

Available implants for fixation have evolved from standard 1/3rd tubular plates, pelvic reconstruction plates, dynamic compression plates to the current techniques using...
pre-contoured fixed angle locking plates with lag screw or headless screw fixation of articular fragments if required. While traditional teaching was that two plates should be oriented at 90 degrees to each other with the lateral plate lying on the posterior surface of the humerus and the medial plate lying at 90 degrees to this (i.e. directly medial) to preclude implant failure, with the advent of stronger plates, this is unnecessary. Biomechanical analysis shows there is no difference between parallel plates or plates at right angles to each other as long as they are locked together with inter-locking screws distally. The most important principle is to ensure that as many of the distal screws as possible engage as many of the individual fracture fragments as possible and that the screws from each plate interlock with one another, which gives the equivalent of an arch which is able to support the whole articular surface more effectively.

Many authors advocate the use of internal fixation in all situations. However, primary elbow replacement is an option in older patients who have low functional demands or have a fracture which is not reconstructable due to the severe comminution or bone loss with or without osteoporosis.

Our preferred method is to use a posterior approach with an olecranon osteotomy to reduce and fix an articular fracture or a triceps turn down if the fracture is extra-articular. We do not transpose the ulnar nerve unless the fracture is distal requiring additional points of screw placement or for better visualization of a medial joint fragment. Fixation is with pre-contoured locking plates to make an arch like construct (Fig. 26). Post-operatively, early active mobilization is encouraged progressing to an increased range of motion and activity as post operative radiographs show adequate healing.

**Practice points-distal humeral fractures**

- **History and examination** - functional demands, age.
- **Radiographs** - intra or extra-articular, CT required?
- **Surgical Management** - approach, transpose ulnar nerve? Fixation or primary arthroplasty.
- **Rehabilitation** - early active mobilization

**External fixation**

The use of hinged external fixation in the treatment of fractures around the elbow is limited to augmentation of internal fixation to provide enhanced stability when adequate fixation is not technically possible or, when, despite adequate fixation the elbow remains unstable such as ‘terrible triad’ injuries. Alternatively, a hinged or non-hinged fixator can be used to bridge an unstable elbow if practicing damage control orthopaedics, where the general condition of the patient does not allow definitive fixation and cast immobilisation is not appropriate.

**Post-operative care**

The final functional outcome after fractures around the elbow is dependent on the overall range of movement achieved. Most activities of daily living require a flexion arc between 30 and 120 degrees. Less than this can give rise to difficulties with eating, dressing or hair care. Post operative stiffness is more commonly seen in cases treated with immobilization for an extended period of time, usually because of inadequate fixation. Therefore stability of fixation to allow early active mobilization as soon as possible is essential; the best results are achieved if immobilisation is limited to 3 weeks or less.
Figure 19  Mehne and Matta classification of distal humeral fractures. A full description is given in the text.
Thus these injuries are treated with an initial period of cast immobilisation to allow the soft tissues to heal, followed by active mobilisation beginning at two weeks. Thereafter an active range of motion regimen concentrates on achieving not only flexion and extension but also pronation and supination which can also be severely affected in these injuries.

The importance of active mobilisation of olecranon fractures treated with tension band wiring has probably been overstated as there is little evidence that tensile forces are converted to compressive forces at the fracture site.23

Complications of elbow fractures and their treatment

Post-operative stiffness

Elbow stiffness which does not respond to physiotherapy may be improved static splinting54,55 and contracture correction devices56 which have proved effective in improving range of motion. Surgical options include manipulation under anaesthesia followed by serial casting.57 However surgical arthrolysis which can be performed open or arthroscopically with equally good results may be necessary to improve range of motion and upper limb function.58,59 The best improvements in range of motion are seen in those

Figure 20  Lateral Radiograph showing Kocher-Lorenz fracture of capitellum with an associated fracture of the radial head.

Thus these injuries are treated with an initial period of cast immobilisation to allow the soft tissues to heal, followed by active mobilisation beginning at two weeks. Thereafter an active range of motion regimen concentrates on achieving not only flexion and extension but also pronation and supination which can also be severely affected in these injuries.

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Figure 21  Bryan and Morrey classification of capitellar fractures with modification by McKee.
with the most limited range of movement to begin with and those less than one year after injury. Initial concerns with neurovascular complications of arthroscopic arthrolysis have been allayed as familiarity with the technique has improved.

Patients older than 65 may be better treated with constrained elbow arthroplasty if resistant to other methods or as a primary measure in this group of patients.

Ulnar nerve dysfunction

The reported incidence is approximately 12% with 5% being permanent. It is not clear from the literature whether these cases represent acute ulnar nerve injury or whether they represent tardy ulnar nerve palsy due to deformity, compression by fibrous and bony tissue or even by prominent metalwork. The incidence of acute ulnar nerve injury either due to trauma or surgical injury is probably around 1%.

Heterotopic ossification

This is relatively uncommon (<3%) in the absence of an injury to the central nervous system, but the incidence increases dramatically if present. The incidence is roughly similar whether the fracture is treated operatively or non-operatively. As aggressive stretching for post operative stiffness is associated with an increased incidence, gentle active mobilisation coupled with continuous passive motion is preferred. (Fig. 27)

Non-union

This is reported to occur in 2–10% of patients, with the non-union typically occurring in the supracondylar rather than intercondylar area. Treatment options available are either further fixation with or without bone graft or conversion to elbow arthroplasty. Several authors report acceptable results with further fixation, but the patients in these studies had a mean age of less

Figure 22  Jupiter and Ring classification of distal humeral articular fractures.
Failure to reconstruct the collateral ligaments, radial head and coronoid process leads to a far higher incidence of instability.\textsuperscript{37}

**Post-traumatic arthritis**

Post-traumatic arthritis is associated with a greater degree of articular involvement,\textsuperscript{71} with 84% of patients having radiological evidence of arthrosis at long-term follow-up in one study.\textsuperscript{48} However, this did not correlate with overall function and rarely required operative intervention.

**Infection**

Most published series report an incidence of infection of \(<5\%\), mostly in open fractures.\textsuperscript{71}

**Secondary procedures**

Secondary procedures in addition to those already discussed are most often performed for prominent metalwork, particularly K-wires backing out following fixation of fracture or osteotomy. Subcutaneous plates on the distal humerus or olecranon may become prominent or cause a restriction in the range of motion and need removing. Ulnar nerve irritation due to implant prominence may require neurolysis or transposition.

Less commonly infection may necessitate a further procedure or the patient may undergo elbow arthroplasty in the presence of post-traumatic arthritis.\textsuperscript{71}

**Conclusion**

While many elbow fractures can be treated conservatively, distal humeral fractures are a major challenge for surgical reconstruction. Understanding the fracture

\begin{figure}
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\includegraphics[width=\textwidth]{figure23}
\caption{Triceps Turndown.}
\end{figure}

\begin{figure}
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\includegraphics[width=\textwidth]{figure24}
\caption{Olecranon Osteotomy-this should be completed through the bare area of the olecranon.}
\end{figure}

Elbow instability is more common after fracture dislocation where the extent of the soft tissue and bony trauma around the elbow may go unrecognised at the time of injury.

than 50 years old. In the older age group consideration should be given to conversion to constrained elbow arthroplasty.\textsuperscript{70}

**Instability**

Elbow instability is more common after fracture dislocation where the extent of the soft tissue and bony trauma around the elbow may go unrecognised at the time of injury.
Figure 25  Complex intra-articular distal humeral fracture managed with elbow arthroplasty.
Figure 26  Complex intra-articular humeral fracture pre and post-fixation. An olecranon osteotomy was used on this occasion.

Figure 27  Heterotopic ossification in a distal humerus fracture.
pattern and stable rigid anatomical fixation with early mobilisation is essential to achieve a good functional outcome. Complications such as elbow stiffness may be amenable to surgical arthrolysis with acceptable functional outcomes.

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References

Fractures of the adult elbow  


