

Approaches for the Upper Extremity

from AO Surgery Reference

Dominik Heim | Shai Luria | Rami Mosheiff | Yoram Weil

7 Forearm shaft

Table of contents

- 7.1** Anterior approach (Henry)
- 7.2** Posterolateral approach
- 7.3** Approach to the ulna
- 7.4** Combined posterior approach
- 7.5** Speed and Boyd's approach
- 7.6** Approaches to the DRUJ
- 7.7** Safe zones for pin placement
- 7.8** Nailing approach for ulna
- 7.9** Nailing approaches for radius
- 7.10** Lateral approach to prox. radius



7.1 Anterior approach (Henry)

Surgical approach

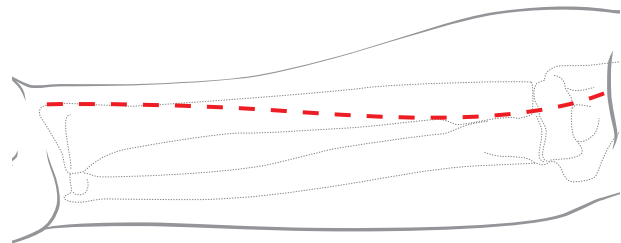
The anterior (Henry) approach offers good exposure of the whole length of the radius. The length of the incision depends on the extent of exposure needed.

Introduction

The anterior (Henry) approach offers good exposure of the whole length of the radius. The length of the incision depends on the extent of exposure needed. The Henry approach in the proximal forearm might result in a more obvious scar.

The landmarks for the skin incision are:

1. Proximally: the biceps tendon which crosses the front of the elbow joint, medial to the brachioradialis muscle. The distal landmark is the radial styloid process.
2. The brachioradialis muscle is part of the mobile wad, comprising the brachioradialis and the extensors carpi radialis brevis and longus.

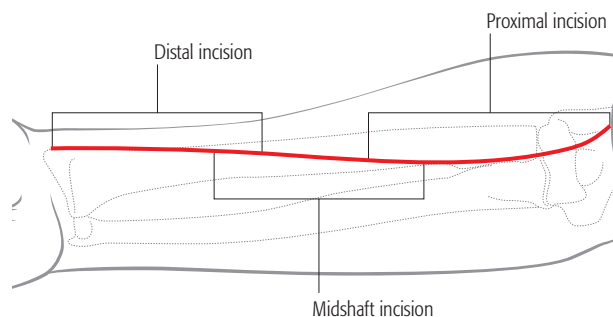




This illustration shows the extents of the incisions for the anterior approaches to the

- proximal third
 - middle third
 - distal third
- of the radial shaft.

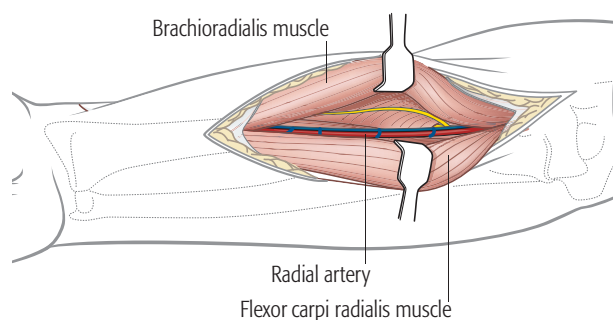
Note: The posterolateral (Thompson) approach also offers good access to either the middle or distal third of the radial shaft.



Superficial dissection

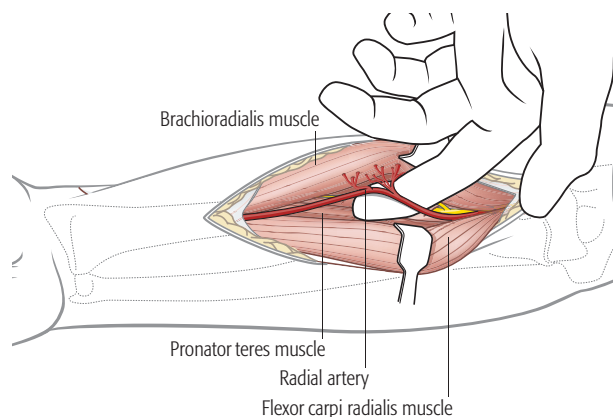
The superficial muscular dissection is similar for all three parts of the Henry anterior approach, illustrated here for the proximal third.

Develop the interval between the brachioradialis (mobile wad) and flexor carpi radialis muscles. The radial artery lies deep to the brachioradialis in the middle part of the forearm and between the tendons of brachioradialis and flexor carpi radialis distally. It can be identified by its two venae comitantes, which run alongside it.



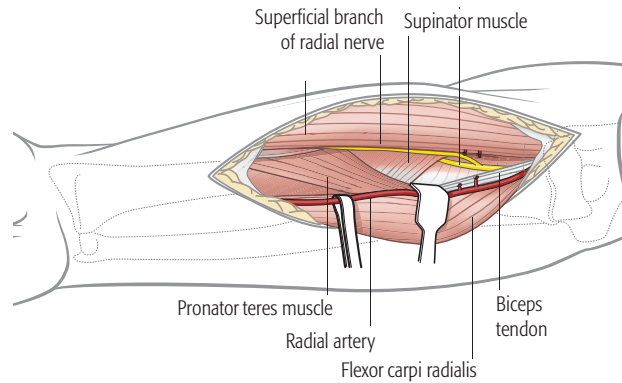
The arterial branches arising from the lateral side of the radial artery are identified by slipping a finger underneath them, lateral to the artery. These are largely the recurrent branches and those to the “mobile wad”.

These branches should be ligated to retract the artery medially.





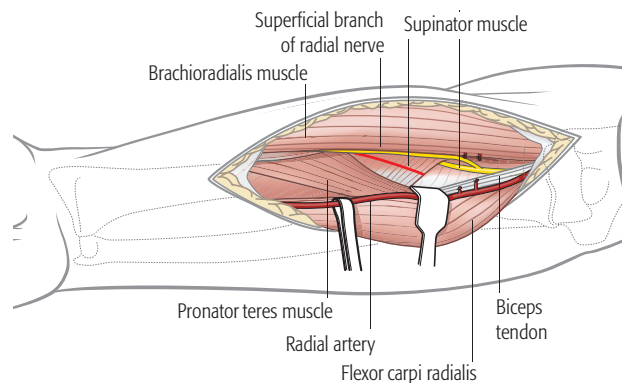
The superficial radial nerve runs under the brachioradialis muscle on the lateral aspect of the radial artery and should be retracted laterally.



Deep dissection: proximal third

The supinator muscle covers the lateral aspect of the proximal radius. The posterior interosseous nerve (also known as deep branch of the radial nerve) lies within the substance of the supinator muscle. The forearm should be fully supinated to displace the posterior interosseous nerve away from the surgical field.

The supinator muscle is then incised along its most medial edge, and gently elevated from the bone surface only to the extent that it is necessary for the required exposure. The plate is inserted deep to the elevated supinator muscle.



Note: Make sure that the plate is seated on the bone without any soft-tissue interposition. In rare cases, the posterior interosseous nerve itself is identified. In such cases it is recommended that the position of the nerve in relationship to the plate be noted and later documented in the operation report.

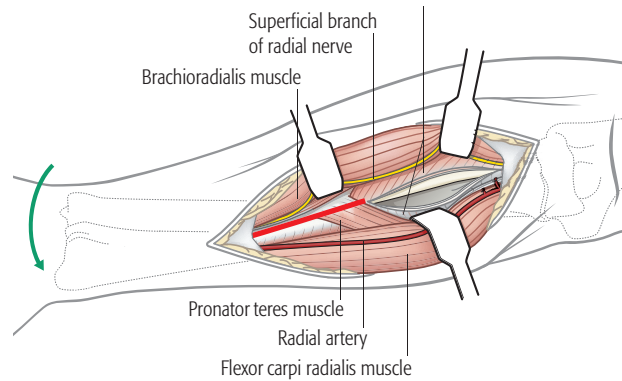




Deep dissection: middle third

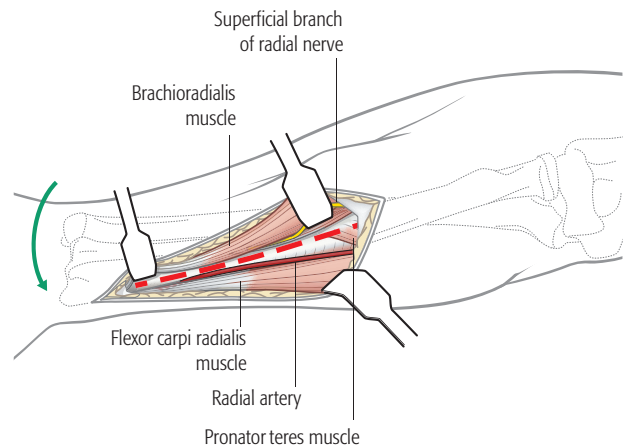
The forearm should be fully pronated to expose the lateral border of the pronator teres muscle and its insertion.

Note: Sometimes it will be necessary to partially detach the pronator teres from the radius. Whenever possible, preserve at least some of its insertion.

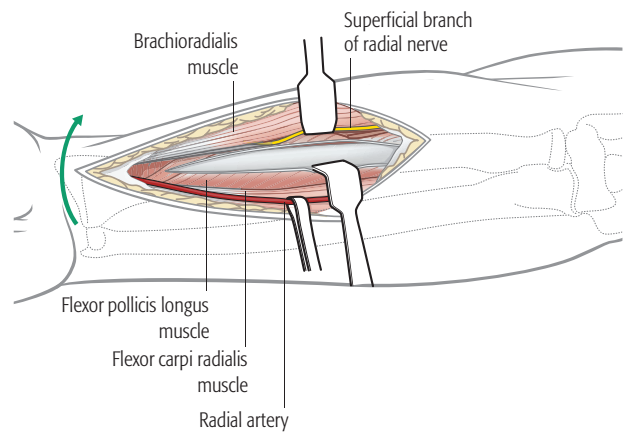


Deep dissection: distal third (classical Henry approach)

Pronating the forearm will expose the aspect of the radius just lateral to the edge of the flexor carpi radialis, deep to which lie flexor pollicis longus and the pronator quadratus, which become visible when the forearm is supinated.



The forearm is again supinated, and the exposure of the bone is completed by any necessary elevation of the flexor pollicis longus and, more distally, pronator quadratus.



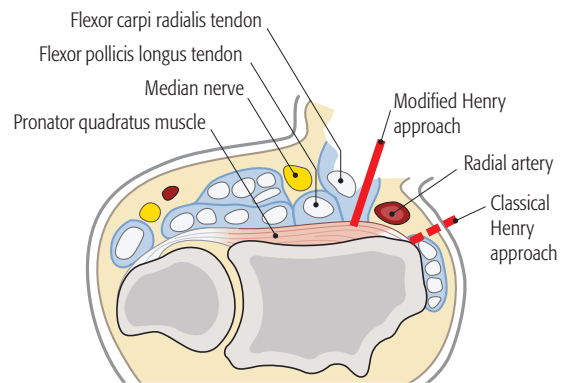


Deep dissection: distal third (modified Henry approach)

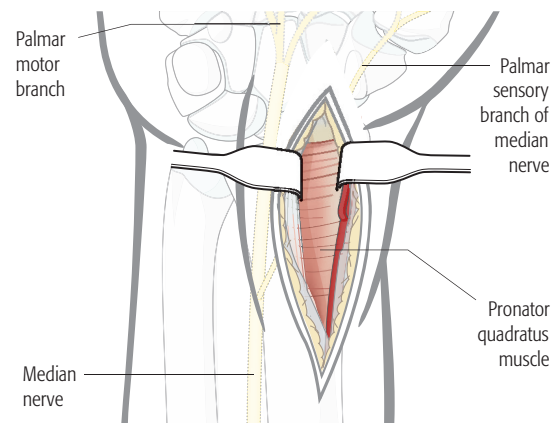
Note: where exposure is likely to be confined to the distal radius only, the following modified Henry approach is preferred by some surgeons.

The modified Henry approach utilizes the interval between flexor carpi radialis tendon and the radial artery, whereas the classical Henry approach goes between brachioradialis and the radial artery. The modified approach is medial to the radial artery.

Note: The radial artery and the palmar branch of the median nerve are vulnerable during this approach.

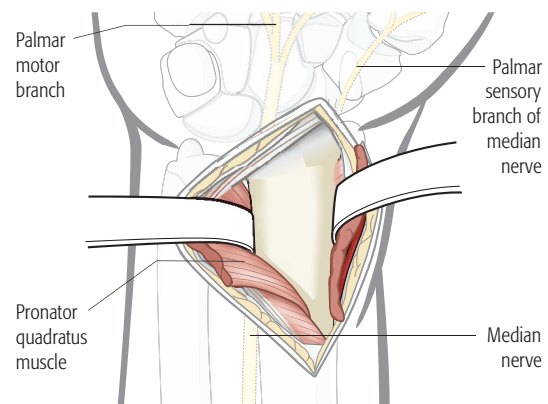


The radial artery is retracted laterally and the flexor carpi radialis is retracted in a medial direction. The pronator quadratus muscle is then exposed by retracting medially the muscle belly of the flexor pollicis longus.



Exposure of the bone is completed by incision of the lateral and distal edges of pronator quadratus muscle leaving a small lateral cuff on the radius to allow for subsequent repair.

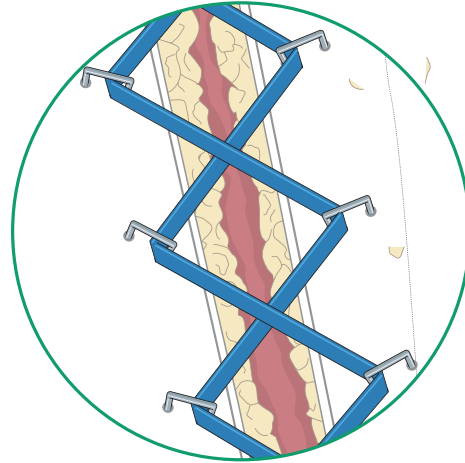
This now allows elevation of the muscle belly from the anterior aspect of the distal radius.





Apart from possible reattachment of pronator quadratus, the anterior deep tissues are left unrepaired. Some subcutaneous sutures are inserted to relieve tension on the skin closure. Wound drainage, either with a closed or an open system, is used. Skin closure is accomplished using interrupted or running sutures, or skin staples.

In certain instances, for example with marked forearm swelling, the wound may have to be left open. There are different techniques to overcome such difficulties (e.g., elastic closure, vacuum assisted closure, petroleum jelly gauze, skin substitute, etc.)

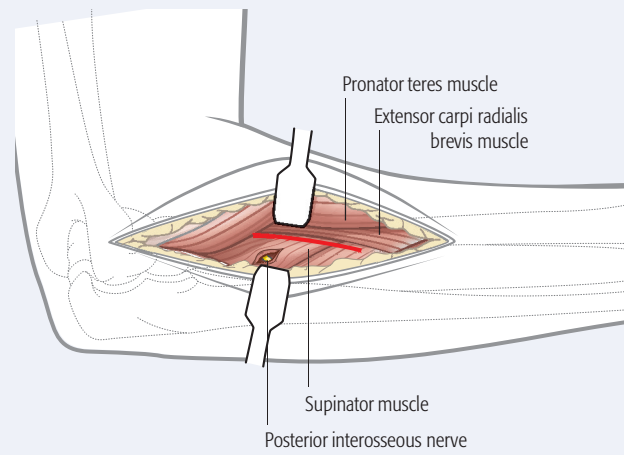




7.2 Posterolateral approach

Surgical approach

The posterolateral (Thompson) approach offers good exposure of the middle and distal thirds of the radial shaft. The skin incision lies straight down the dorsal aspect of the forearm and its length depends on the exposure needed. Posterolateral approach (Thompson)

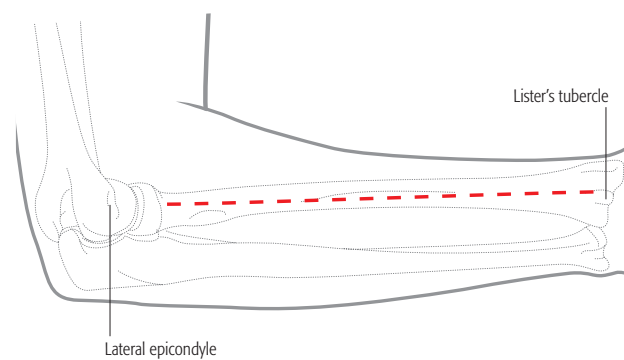


Introduction

The posterolateral (Thompson) approach offers good exposure of the middle and distal thirds of the radial shaft. The skin incision lies straight down the dorsal aspect of the forearm and its length depends on the exposure needed.

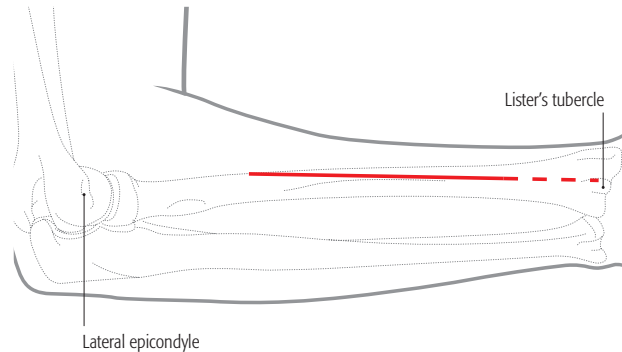
The landmarks for skin incision are:

1. Proximally: the lateral epicondyle (note that the skin incision will not extend to the lateral epicondyle)
2. Distally: Lister's tubercle



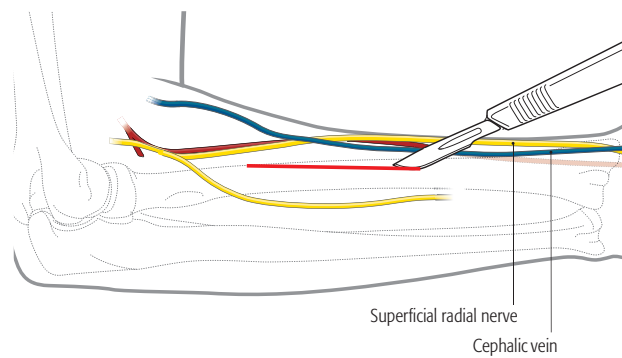


This illustration shows the extent of the posterolateral approach to the middle third of the radial shaft with an extension to its distal third.



Skin incision

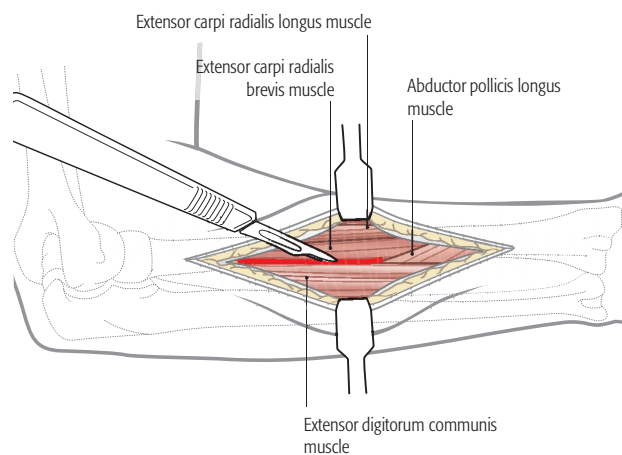
Incise the skin and subcutaneous tissues. In the distal part of the incision, be aware of the superficial radial nerve and the cephalic vein.



Deep dissection – middle third

The distal starting point of the deep dissection is the proximal border of the oblique crossing of the abductor pollicis longus muscle over the dorsal surface of the radius. Development of the plane deep to the abductor pollicis longus allows the belly to be lifted with a retractor to give access to the underlying radius.

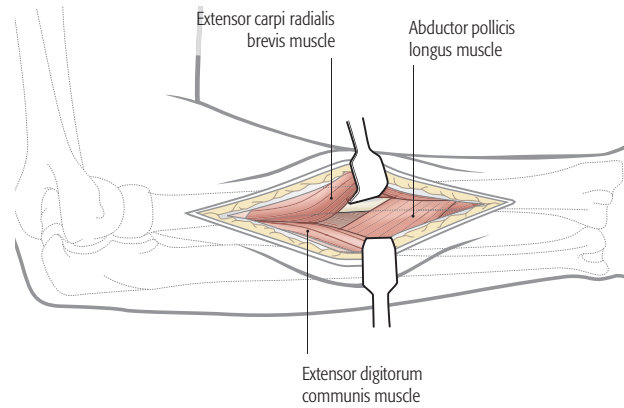
Continue the dissection proximally between the extensor carpi radialis brevis, which should be retracted laterally, and the extensor digitorum communis which should be retracted medially.



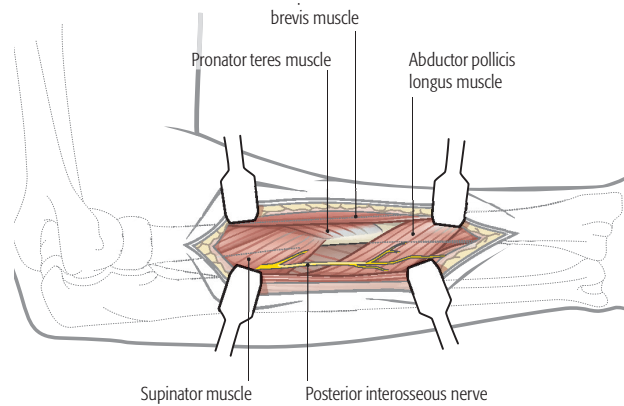


Exposure of the supinator and abductors pollicis

The retraction of the extensor carpi radialis brevis and the extensor digitorum communis will expose...



... the supinator proximally and the rest of the abductor pollicis longus distally.

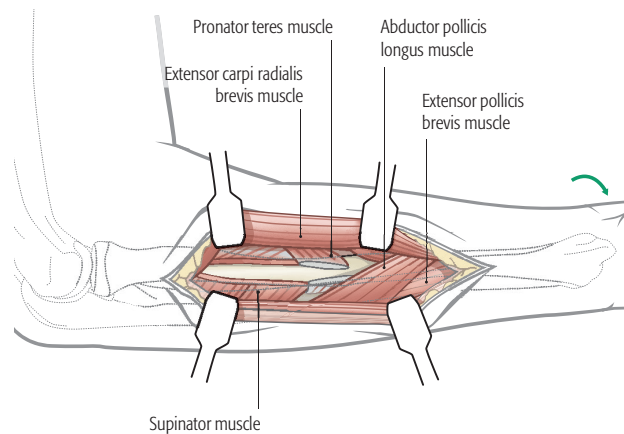


Turn the arm

Turn the arm in full supination to bring the origin of the supinator into view and to move the posterior interosseous nerve away from the area of dissection.

Some elevation of the supinator attachment to the radius is usually necessary to expose the underlying shaft.

If it is necessary to mobilize the pronator teres, should the fracture configuration demand, it can be partially divided at its insertion into the radius, leaving sufficient tendinous cuff attached to the radius to aid subsequent repair.



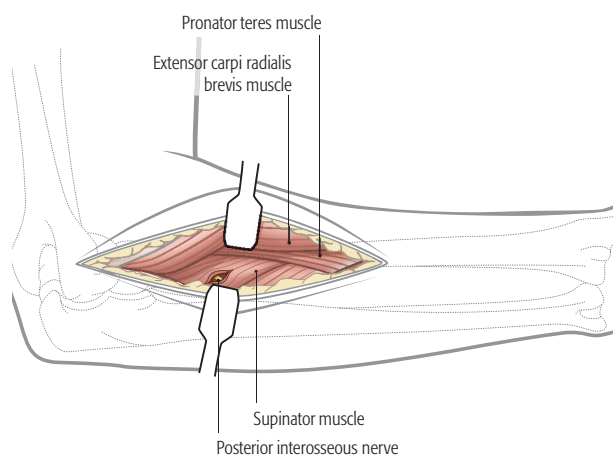


Deep dissection – extension to proximal third

Note: Proximal extension of the exposure of the middle third carries considerable risk unless great care is taken to avoid injury of the posterior interosseous nerve.

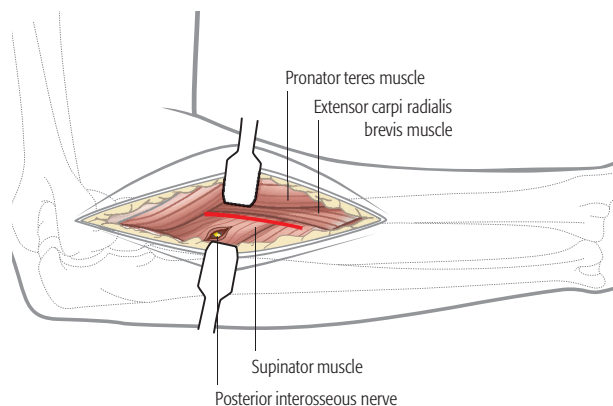
Identify the posterior interosseous nerve

The supinator wraps around the upper part of the radius. The posterior interosseous nerve runs within its substance. The nerve must be identified and protected as it traverses the muscle. To verify the position of the posterior interosseous nerve, a small hole can be made into the supinator muscle. The nerve can also be felt as a bulge in the muscle.



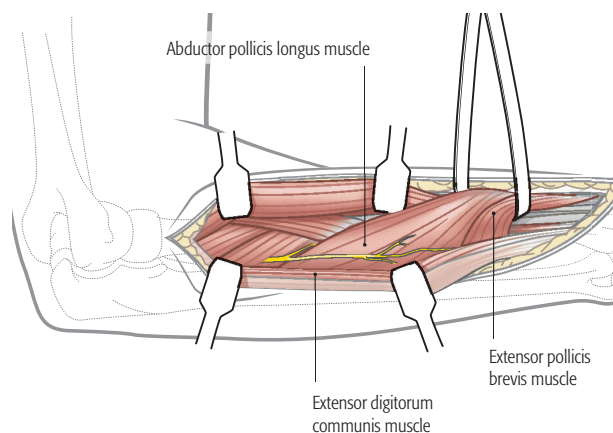
The elevation of the supinator involves an incision along its insertion into the radius. This may be aided by a degree of supination of the forearm.

The supinated muscle should be elevated subperiosteally, to protect the posterior interosseous nerve.



Distal extension

Extend the skin incision to the Lister's tubercle. Undermine the abductor pollicis longus and extensor pollicis brevis and lift them up with a vessel loop. Towards the Lister's tubercle, retract the tendon of the extensor carpi radialis longus laterally. Distally, a partial incision of the extensor retinaculum is often necessary: respect the extensor pollicis longus tendon on the medial side of the tubercle.

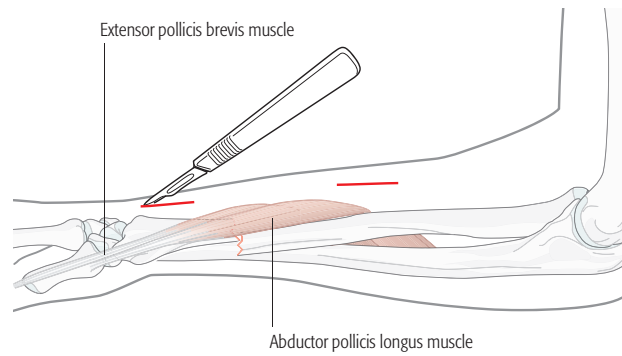




Approach for minimally invasive techniques

An option to the described open approach is the minimally invasive approach, making two small incisions proximal and distal to the abductor pollicis longus muscle.

This approach is described with the detailed procedure.

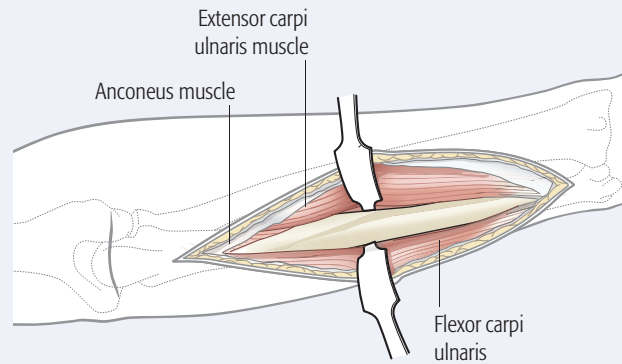




7.3 Approach to the ulna

Surgical approach

The standard ulnar approach offers good exposure along the whole ulnar shaft. The length of the incision depends on the exposure needed.



Introduction

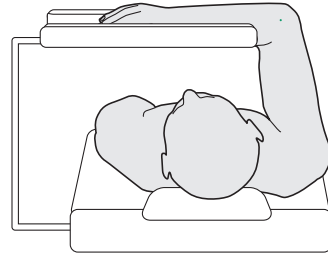
In the following, we shall illustrate the approach to the middle and distal thirds of the ulnar shaft. This approach can be extended both proximally and distally.



Positioning of the forearm

The positioning of the arm for an approach to the ulna will depend on whether a radial fracture fixation is also necessary.

In isolated ulnar fractures, reduction is often aided by holding the arm in neutral pronation/supination.

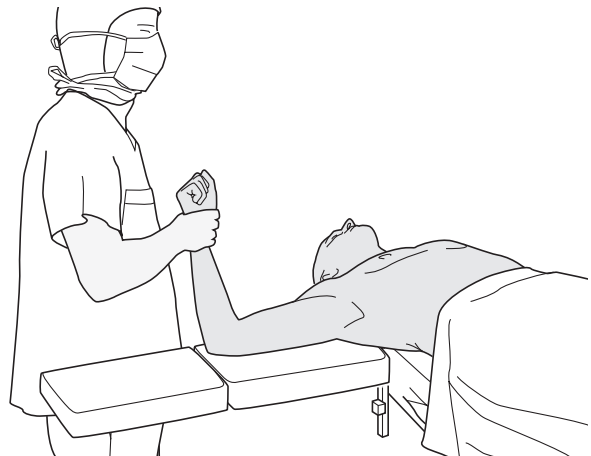


Isolated ulnar fracture - arm across the torso

In isolated ulnar fractures, some surgeons prefer to place the patient's arm over the chest to allow for comfortable access.

Isolated ulnar fracture - arm on side table

There are surgeons who prefer the arm at the side with the elbow resting on a side table and the forearm held vertically.



Ulnar fracture with radial fracture

The arm is usually positioned on a side table to permit the appropriate radial approach. The ulnar fixation is performed with the forearm held vertically and the elbow resting on the side table.



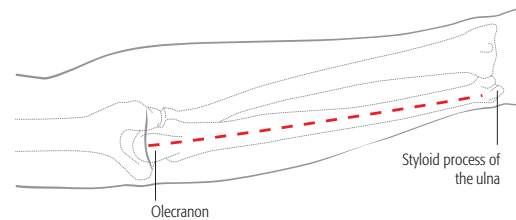


Skin incision

The standard ulnar approach offers good exposure along the whole ulnar shaft. The length of the incision depends on the exposure needed.

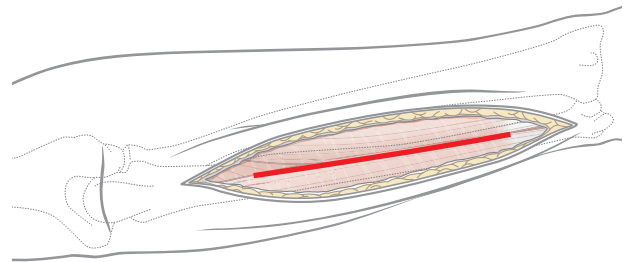
The skin incision follows the subcutaneous border of the ulna, along a line drawn between the tip of the olecranon process and the ulnar styloid process.

Pearl: If the forearm is markedly swollen, it may not be possible to close the skin of the ulnar approach. In these circumstances, it is better to plan the skin incision over the adjacent extensor muscle compartment, so that an open incision will have a muscular bed rather than exposing the implant.



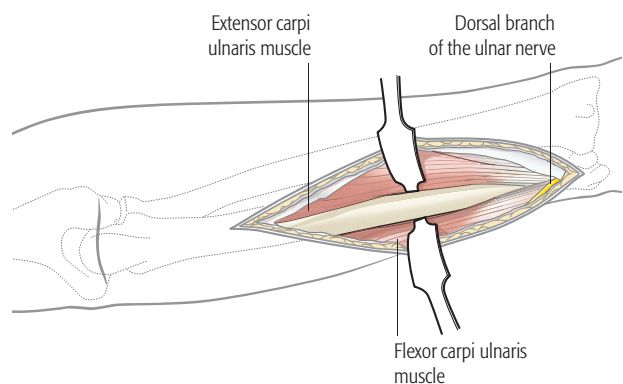
Deep dissection

The deep dissection should be carried out in the interval between the flexor carpi ulnaris and the extensor carpi ulnaris muscles.



Dorsal branch of the ulnar nerve

In a very distal extension of the ulnar approach, take care to avoid injury to the dorsal branch of the ulnar nerve, as it runs to the back of the hand.





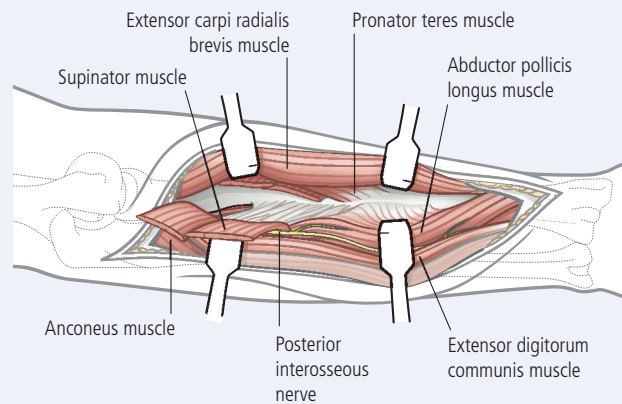
7.4 Combined posterior approach

Surgical approach

The proximal third of the shaft of the ulna and the proximal two thirds of the shaft of the radius can be reached by using a single incision.

The main drawback of this combined approach is an increased risk of synostosis.

Combined posterior approach to radius and ulna



General considerations

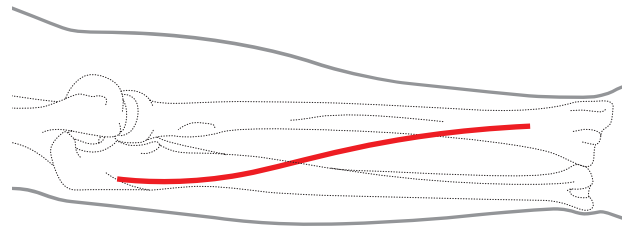
The proximal third of the shaft of the ulna and the proximal two thirds of the shaft of the radius can be reached by using a single incision. This approach is very unusual, and it is rarely used, only perhaps, in patients with large dorsal soft-tissue wounds.

Pitfall: The main drawback of this combined approach is an increased risk of synostosis.



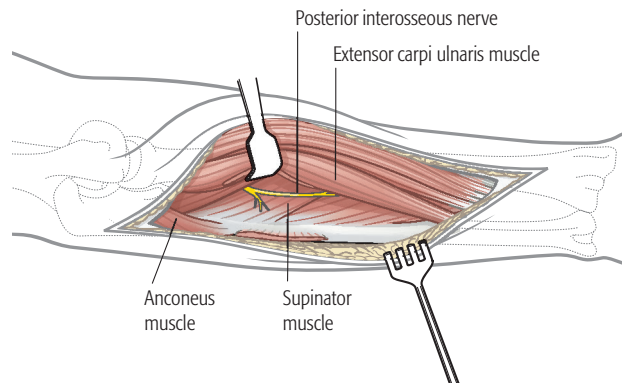
Skin incision

With the forearm in mid-pronation, make a skin incision starting proximally between the olecranon and the lateral epicondyle, and curving distally over the proximal third of the ulna and over the middle third of the radius.



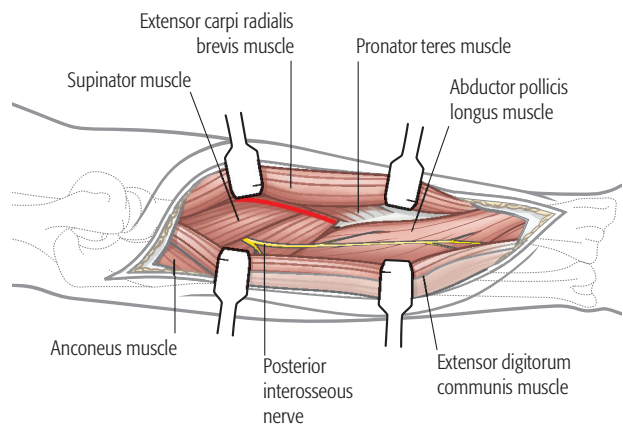
Dissection

Deepen the proximal half of the incision to expose the subcutaneous and adjacent radial surfaces of the ulna, retracting the extensor carpi ulnaris laterally, elevating it from the bone extraperiosteally.



Dissection of the radius

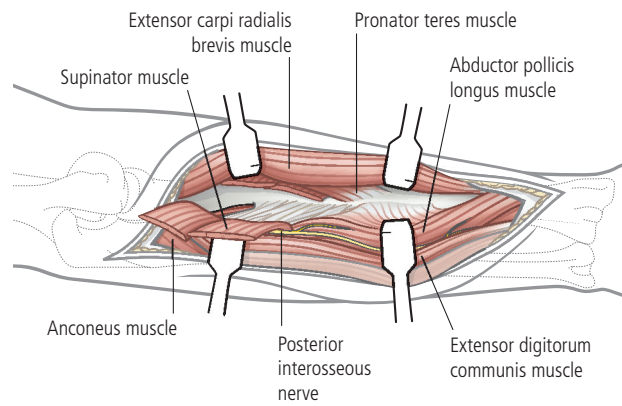
Expose the proximal two thirds of the radius shaft by splitting the seam between the extensor carpi radialis brevis and the extensor digitorum communis. By this maneuver the supinator muscle is exposed. Identify the posterior interosseous nerve within this muscle.





Retraction of supinator muscle

After identification of the posterior interosseous nerve, longitudinally divide the insertion of the supinator muscle into the lateral aspect of the radius, and retract it medially, together with the extrinsic muscles of the thumb.

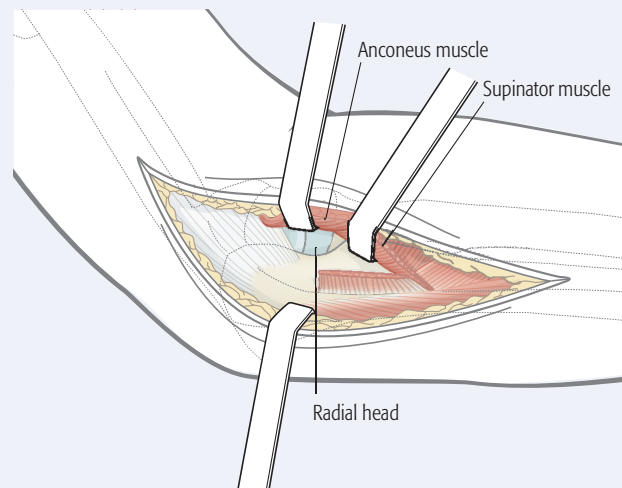




7.5 Speed and Boyd's approach

Surgical approach

This approach gives good exposure for fractures that include proximal ulnar shaft fractures and disorders of the radial head. It can be used for Monteggia injuries with persistent displacement of the radial head after anatomical reduction and fixation of the ulnar fracture.



Introduction

This approach gives good exposure for fractures that include proximal ulnar shaft fractures and disorders of the radial head. It can be used for Monteggia injuries with persistent displacement of the radial head after anatomical reduction and fixation of the ulnar fracture.

Its advantage is that both lesions (ulnar fracture and radial head dislocation) can be accessed via a single approach.

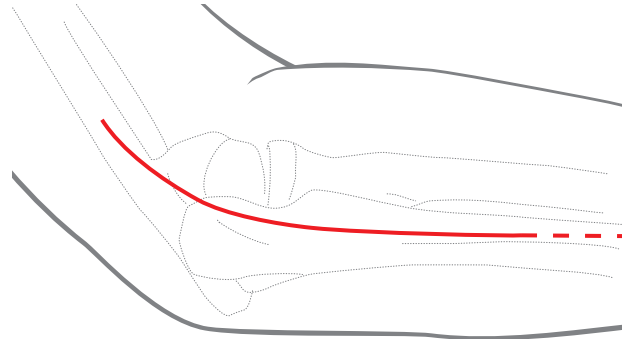
In Monteggia injuries, the decision-making is based on the direction of the dislocation of the radial head. Posterior dislocation is addressed via the Speed and Boyd approach and anterior dislocation via the lateral approach.



Skin incision

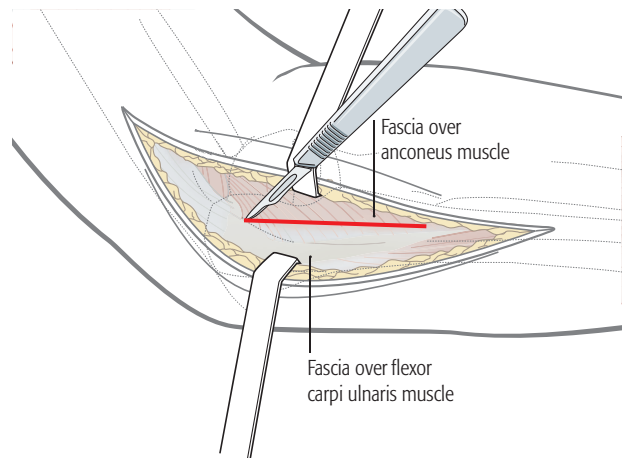
The skin incision begins proximal to the elbow and lateral to the triceps tendon. It curves distally over the lateral aspect of the tip of the olecranon, and continues along the subcutaneous border of the ulna.

Note: This approach is useful to reach both bones in their proximal portions via a single incision. However, there is an increased risk of synostosis (as in any combined approach to both the radius and ulna).



Dissection

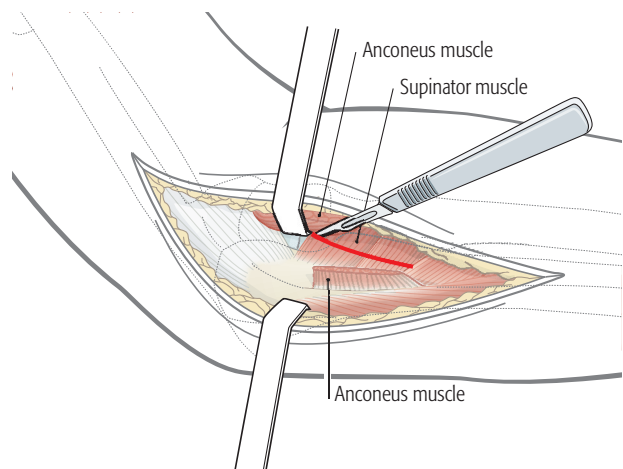
Incise the deep fascia in line with the incision to approach the lateral margin of the ulna between the anconeus insertion and the flexor carpi ulnaris.



Expose the radial head

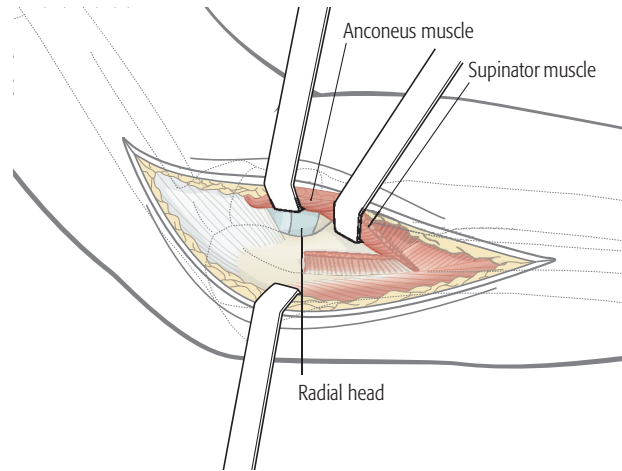
The anconeus muscle is reflected anteriorly/laterally after incising its ulnar insertion.

The next layer is the supinator muscle that is detached near its ulnar origin.





The anconeus and supinator muscles are then freed from the posterior aspect of the interosseous membrane, carefully protecting the posterior interosseous nerve, which is within the substance of the supinator muscle. By retracting these muscles, the posterior joint capsule over the radial head is exposed, allowing the repair of the posterior capsule and/or annular ligament.

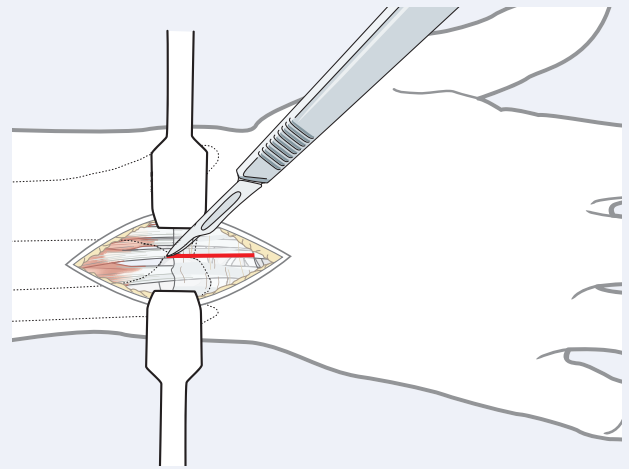




7.6 Approaches to the DRUJ

1 Surgical approach

Approaches to the distal radioulnar joint (DRUJ) become necessary in cases in which ulnar head dislocations, in the context of Galeazzi injuries, cannot be reduced closed. Approaches to the DRUJ (posterior/anterior)



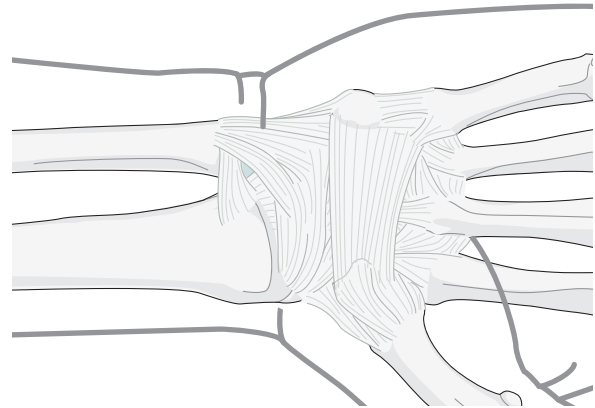
2 Indication

Approaches to the distal radioulnar joint (DRUJ) become necessary in cases in which ulnar head dislocations, in the context of Galeazzi injuries, cannot be reduced closed. In majority of cases, the displacement of the ulnar head is posterior. Very rarely, it dislocates anteriorly. The approach chosen (whether posterior or anterior) depends on the direction of the displacement.



Anatomical consideration

Anatomically, in contrast to the proximal radioulnar joint, there are no clearly defined ligamentous structures in the DRUJ. It is simply a strong joint capsule.

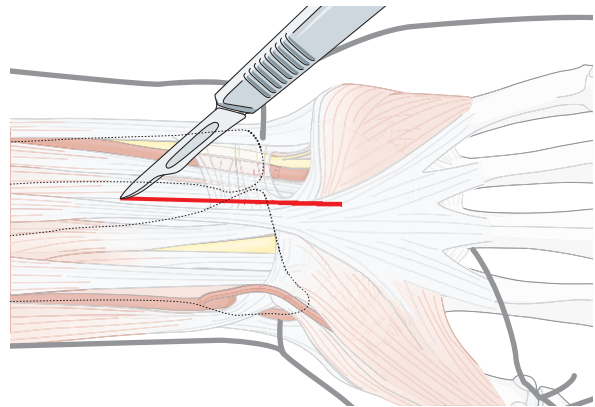


Anterior approach – structures at risk

Be aware of the median nerve to the radial side and the ulnar nerve and vessels to the ulnar side.

Anterior approach - skin incision

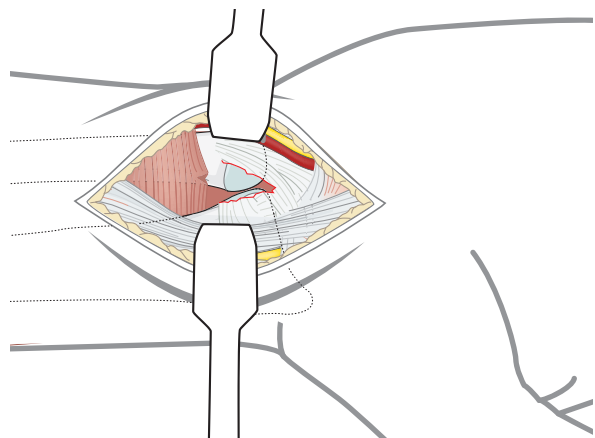
Incise the skin on the medial aspect of the palmaris longus tendon. Be aware of the ulnar nerve and vessels that run along on the lateral aspect of the flexor carpi ulnaris tendon.



Anterior approach - deep dissection

Retract laterally the palmaris longus tendon, median nerve and all flexor tendons. The ulnar nerve and vessels are retracted to the medial side; the distal portion of the pronator quadratus is incised longitudinally, thereby exposing the torn distal articular capsule and the dislocated ulnar head.

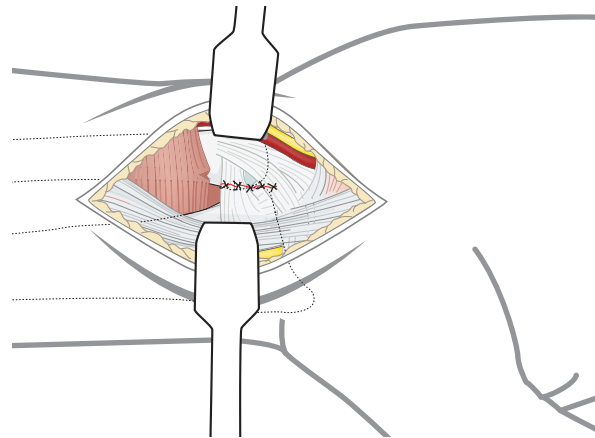
Do not retract the median nerve medially, as this would damage the palmar branch of the median nerve.





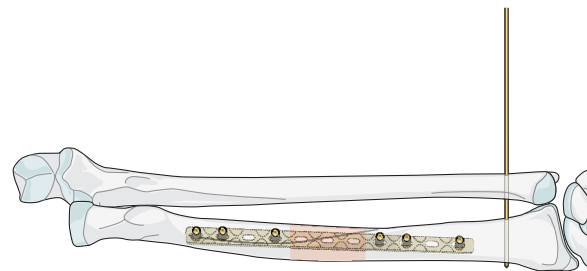
Anterior approach – repair of articular capsule

Reduce the ulnar head by pronation and suture the torn ends of the articular capsule using interrupted resorbable sutures.



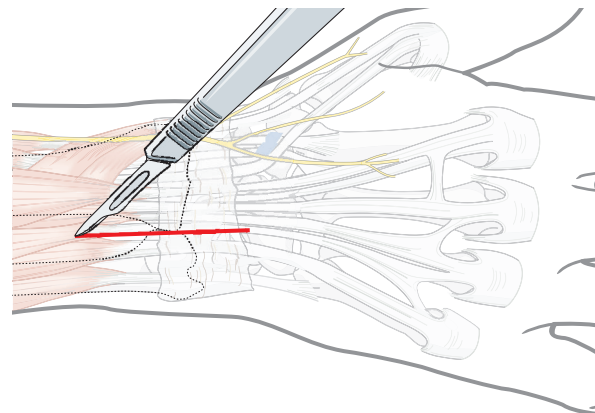
To avoid any redislocation, temporary K-wire transfixation is necessary.

Insert the K-wire(s) in the position of the forearm in which a stable reduction was achieved, i.e., mostly in a neutral or supinated position (as illustrated). The transfixion wire is usually retained for approximately 3 weeks. Most surgeons recommend cast protection during the time of K-wire fixation, to prevent forearm rotation.



Posterior approach – skin incision

Incise the skin longitudinally in the interval between the ulna and the radius, over the DRUJ.

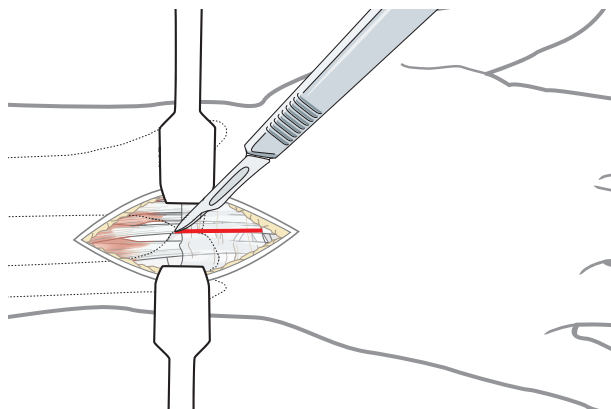




Posterior approach – deep dissection

Incise the extensor retinaculum between the 4 and 5 extensor tendon compartments. Retract the extensor digitorum tendons to the lateral side and the extensor tendons to the little finger to the medial side.

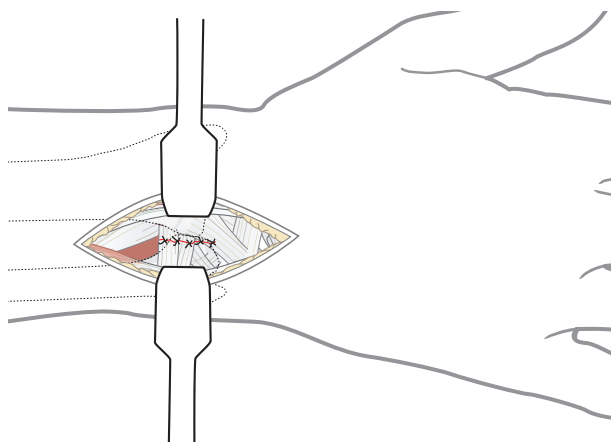
Ligate any venous branches of the superficial vein complex.



Posterior approach – repair of articular capsule

Reduce the ulnar head, usually by supination after posterior dislocation, and suture the torn ends of the articular capsule with interrupted stitches of resorbable material. To avoid any redislocation, temporary K-wire transfixation is necessary, with the forearm in the rotational position that led to maximal stability of the DRUJ.

The transfixion wire is usually retained for approximately 3 weeks. Most surgeons recommend cast protection during the time of K-wire fixation, to prevent forearm rotation.

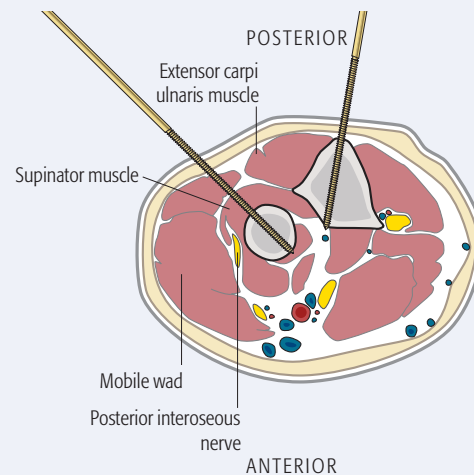




7.7 Safe zones for pin placement

Safe zones for pin placement

The forearm anatomy is complex due to the presence of three major neurovascular bundles.

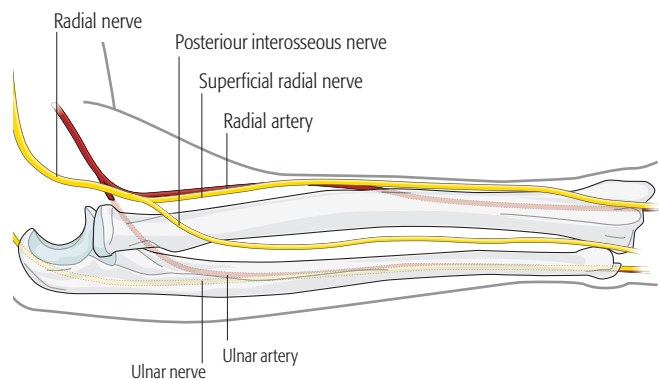


Anatomical considerations

The forearm anatomy is complex due to the presence of three major neurovascular bundles.

In particular:

- Radial nerve with its two branches (i.e., posterior interosseous nerve and superficial radial nerve)
- Radial artery





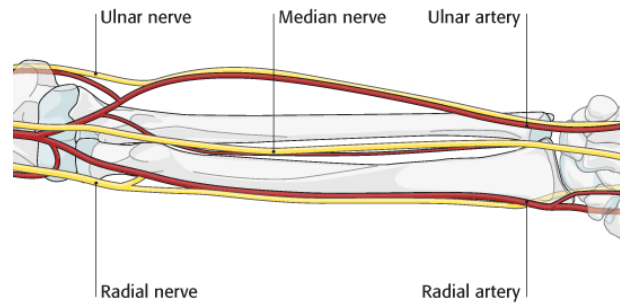
- Median nerve
- Ulnar nerve
- Ulnar artery

Except for the radial nerve, all previously mentioned structures run in the flexor compartment anteriorly.

Note: the cephalic vein runs parallel to the superficial radial nerve in the distal part of the forearm.

Pitfall: The more proximal the surgical field, the greater the risk of damage to important structures!

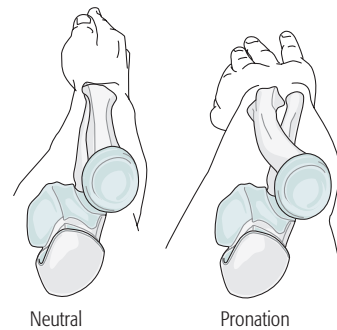
Usually pin insertion is via the posterolateral aspect of the radius. Avoid anterior pin insertion.



Forearm position

The anatomical relationships are complex because they depend on the rotational orientation. For pin insertion, two forearm positions are most often used:

- Pronation – for the ulna
- Neutral rotation (between pronation and supination) – for the radius



Skin tension

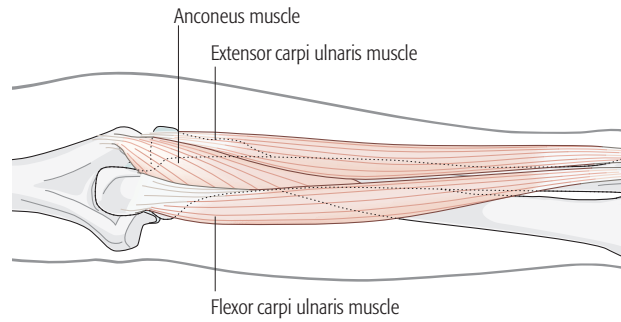
Pins should be inserted at sites where the soft-tissue envelope is as thin as possible. Moreover, the pins should be inserted between muscle compartments, not through them.





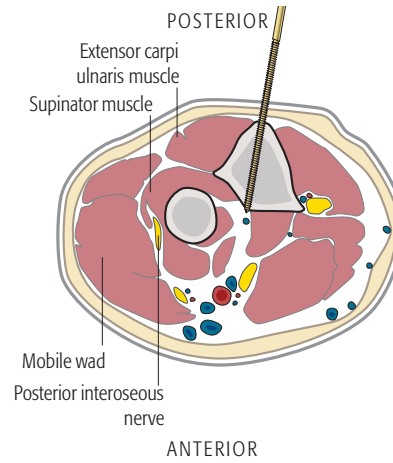
Safe zones in the ulna (pronation)

Safe zones for ulnar pin insertion are along the whole shaft between the extensor carpi ulnaris and the flexor carpi ulnaris.

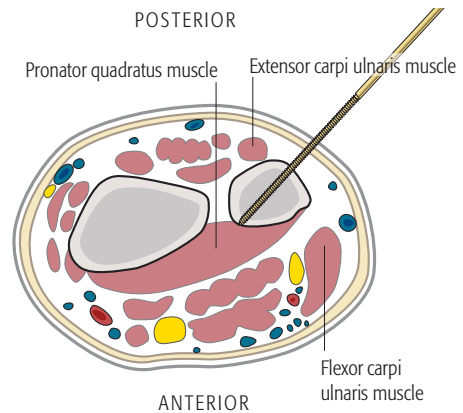


Safe zones in the ulna

This cross section illustrates a pin inserted into the proximal ulna.



This illustration shows a pin inserted into the distal ulna.

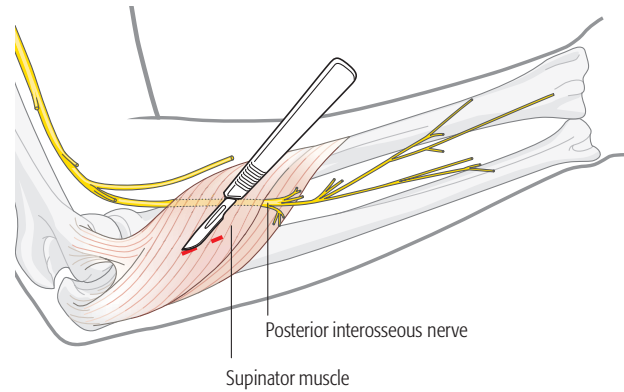




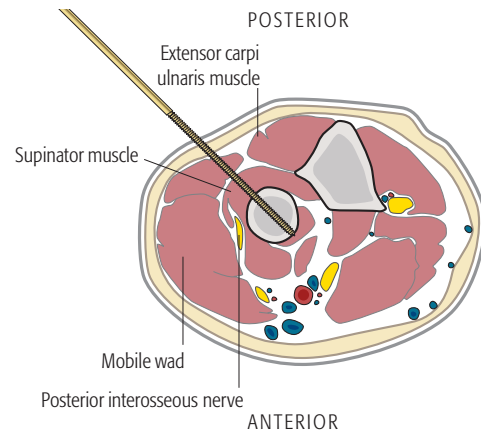
Safe zones in the proximal radius

The radial nerve is vulnerable in this zone. The supinator muscle cloaks the dorsal aspect of the upper 3rd of the radius, with the posterior interosseous nerve running through its substance.

A skin incision is made and then progressively deepened by spreading a forceps and advancing the retractors layer by layer until the bone is reached.

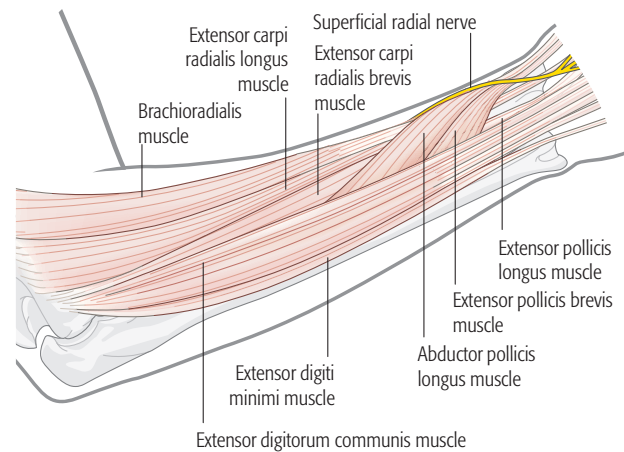


This cross section illustrates a pin inserted into the proximal third of the radius. Beware of the posterior interosseous nerve!



Safe zones in the distal radius

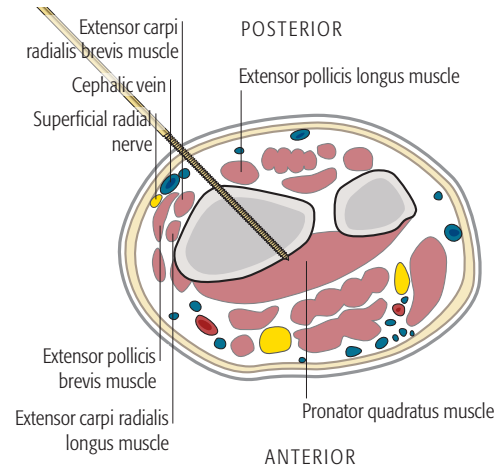
Beware of the superficial radial nerve and outcropping muscles or extensor tendons.





This illustration shows the distal third of the forearm. Any pins need to be inserted under direct vision using retractors down to the bone to avoid the superficial branch of the radial nerve.

A skin incision is made and then progressively deepened by spreading a forceps and advancing the retractors layer by layer until the bone is reached.

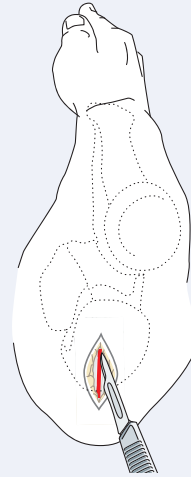




7.8 Nailing approach for ulna

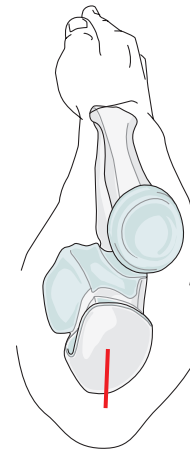
Surgical approach

With the patient in supine position and the arm in pronation on an arm table, make a straight longitudinal, approximately 1 cm long incision at the tip of the olecranon.



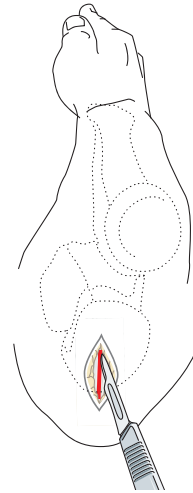
Approach to the ulna for intramedullary nailing

With the patient in supine position and the arm in pronation on an arm table, make a straight longitudinal, approximately 1 cm long incision at the tip of the olecranon.





Split the triceps tendon down to the bone.

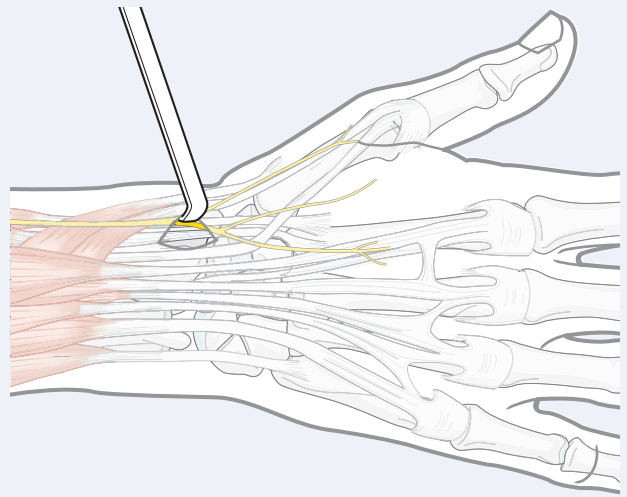




7.9 Nailing approaches for radius

Surgical approach

The correct nail entry point and so the chosen approach depends on the nail type used.

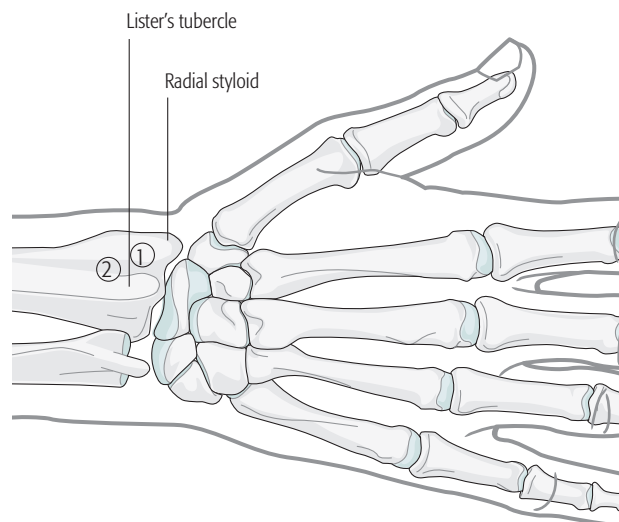


Introduction

The correct nail entry point and so the chosen approach depends on the nail type used. The following entry points are used:

1. On the ulnar side of the radial styloid, between the first and second extensor tendon compartments
2. On the radial side of the Lister's tubercle, between the second and third extensor tendon compartments

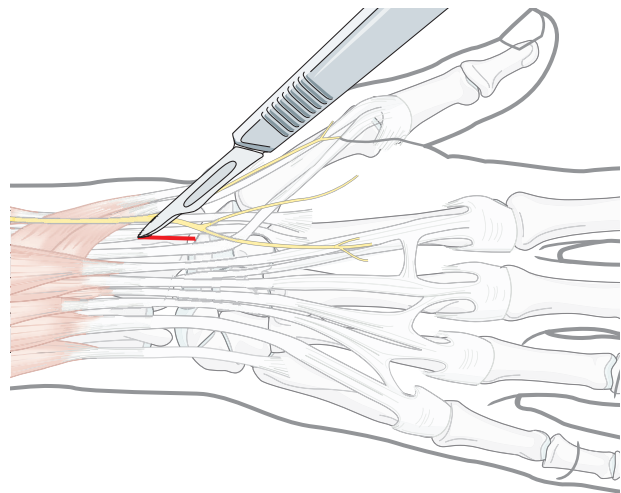
In the following, we shall describe the approach to the radial side of the Lister's tubercle (**2**). For other approaches, please refer to the manual of your chosen nail system.





Skin incision

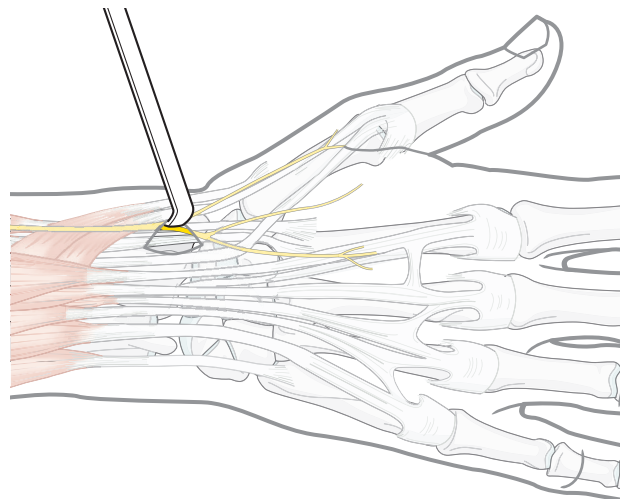
Make a 2.5 to 3 cm longitudinal skin incision over the distal radius on the radial side of Lister's tubercle.



Deep dissection

Bluntly dissect subcutaneous tissues to avoid injury to the dorsal branches of the superficial radial nerve, which cross the tendons closely.

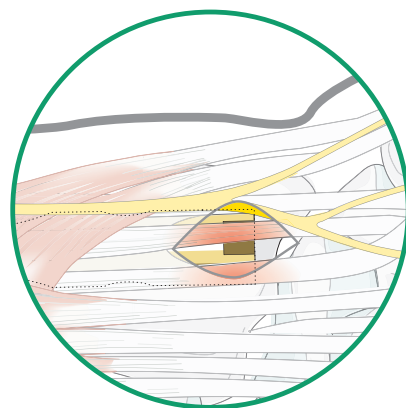
A skin incision is made and then progressively deepened by spreading a forceps and advancing the retractors layer by layer until the bone is reached. It may be necessary to incise a portion of the extensor retinaculum.



Pitfalls

Any entry point near the Lister's tubercle can damage the extensor tendons of the second and third compartments, especially when the nail is prominent.

Complete division of the extensor retinaculum can result in tendon subluxation ("bowstringing").

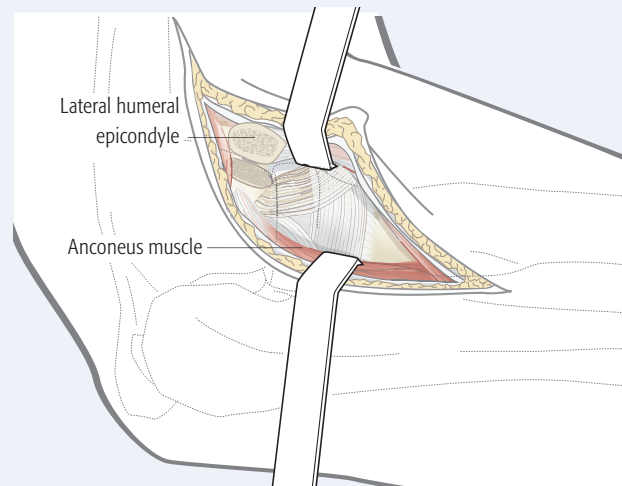




7.10 Lateral approach to proximal radius

Surgical approach

The lateral approach can be used to access the radial head.
Lateral approach to the proximal radius

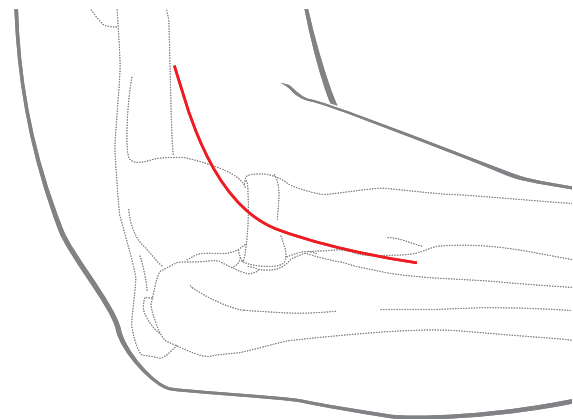


Skin incision

Start the incision 2 cm proximal to the lateral humeral epicondyle.

Carry the incision across the elbow joint, over the radial head, and approx. 5 cm distal to the joint.

Note: The posterior interosseous nerve, within the supinator muscle, crosses the posterior radius, from anteriorly, three finger-breadths distal to the radial head. It must be protected during this approach.



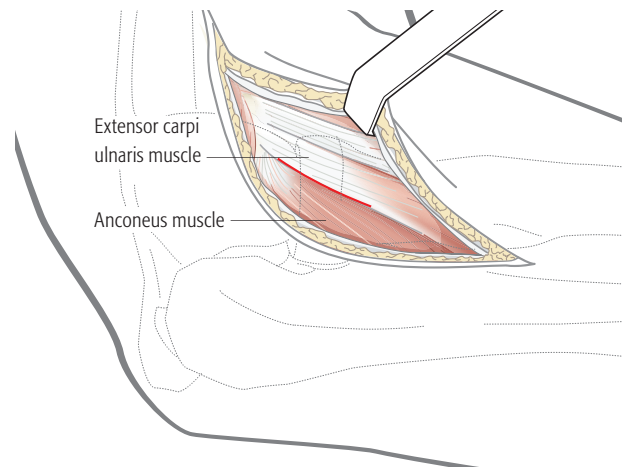


Superficial surgical dissection

Incise the subcutaneous tissue and deep fascia in line with the incision.

Elevate anterolaterally the subcutaneous tissue and find the interval between the anterior border of the anconeus and the extensor carpi ulnaris muscle.

There may be difficulties in determining the interval between these two muscles because of bruising and bleeding in trauma.

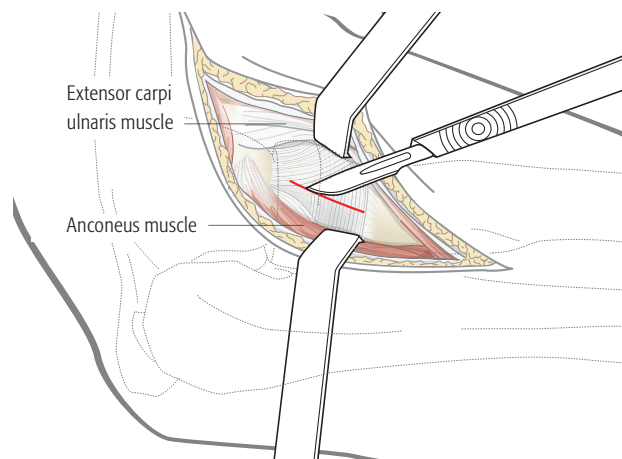


Deep surgical dissection

Separate anconeus from extensor carpi ulnaris. Elevate them from the joint capsule.

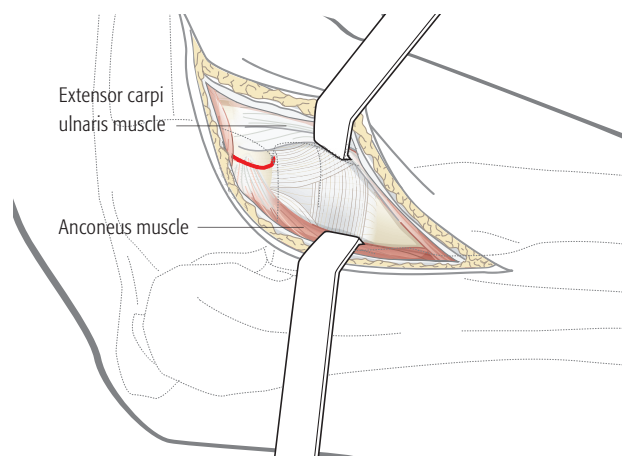
Incise the joint capsule to expose the radial head and the annular ligament.

Note: The annular ligament is entered 1 cm anterior to the ulna to prevent injury to the lateral ulnar collateral ligament.



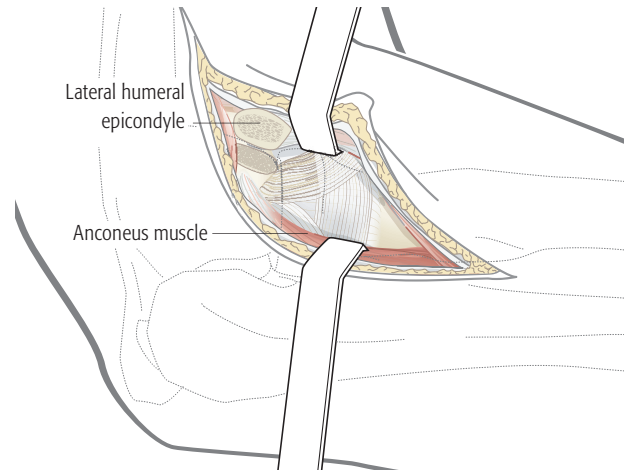
Osteotomy of lateral epicondyle

A variation for lateral exposure with preservation of collateral ligaments and extensor tendon origin involves osteotomy of the lateral humeral epicondyle. The osteotomy line in the illustration is marked in red.





The soft tissues and epicondyle are reflected anteriorly to provide access to the proximal radius and ulna. Repair after this approach requires fixation of the epicondyle. The necessary screw hole can be drilled before the osteotomy.



Avoiding damage to radial nerve

Fully pronating the forearm protects the posterior interosseous nerve by moving it away from the operative field. Beware of incising the capsule too far anteriorly as the radial nerve lies over the front of the anterolateral portion of the elbow capsule. Beware of dissection distal to the annular ligament or strenuous retraction, because the posterior interosseous nerve lying within the supinator muscle is at risk.

