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## 5 Distal humerus

### Table of contents

- 5.1** Lateral approach (Kaplan)
- 5.2** Medial approach
- 5.3** Transolecranon approach
- 5.4** Posterior triceps-on approach
- 5.5** Triceps-elevating approach
- 5.6** Safe zones
- 5.7** Anterior approach



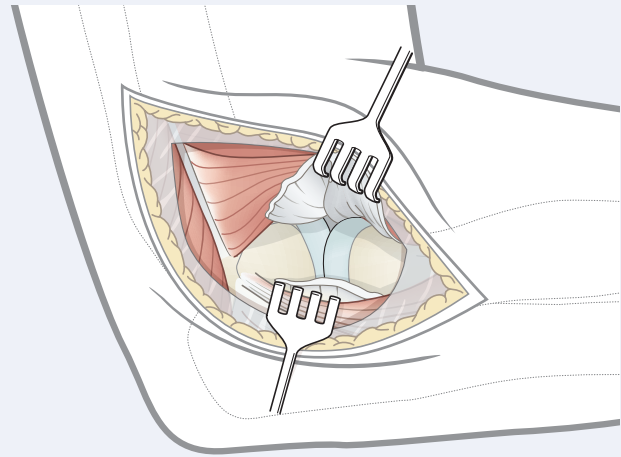


## 5.1 Lateral approach (Kaplan)

### Surgical approach

The Kaplan approach is a frequently used lateral approach which provides excellent exposure of the:

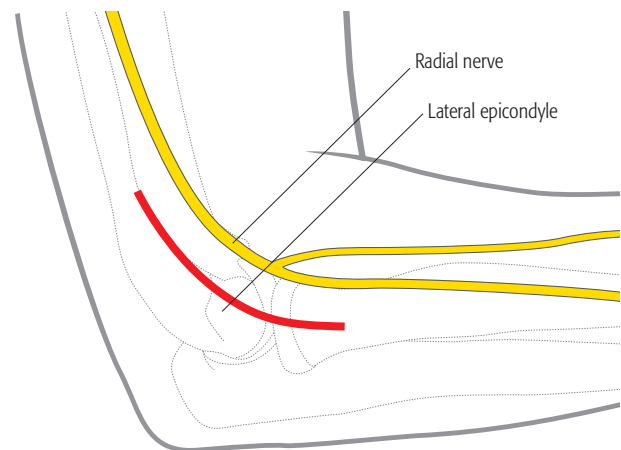
- Proximal radius
- Anterior facet of the coronoid process
- Anterior facet of the distal humerus



### Skin incision

The incision starts over the lateral supracondylar ridge, 5 cm proximal to the elbow joint. It passes distally to the lateral surface of the proximal forearm, posterior to the radial head.

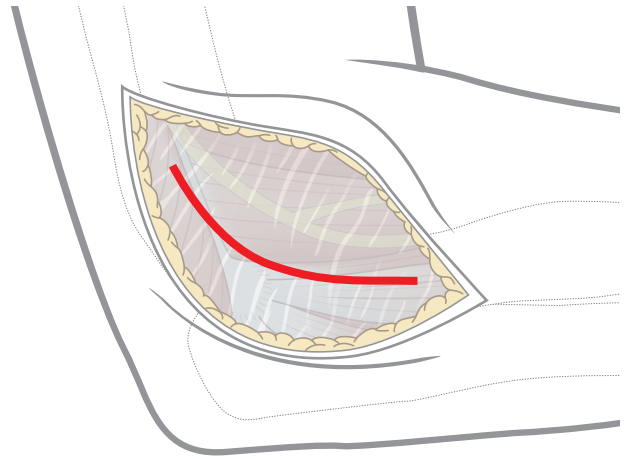
**Note:** Be careful of the radial nerve, which runs close to the radial head and neck. It divides into its superficial and deep branches at the level of the radial head.





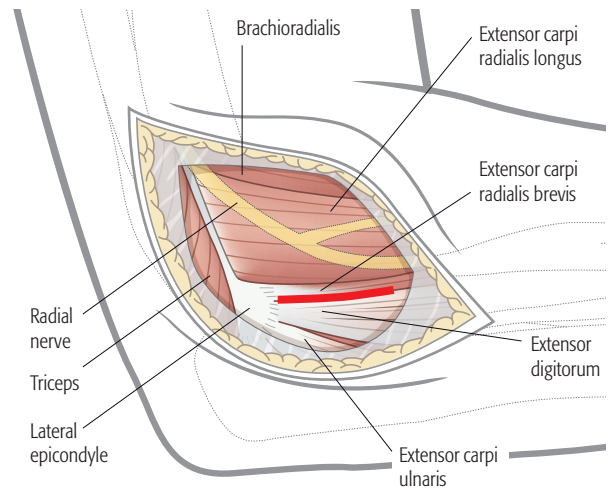
### Deep dissection

The deep fascia is incised in line with the skin incision.

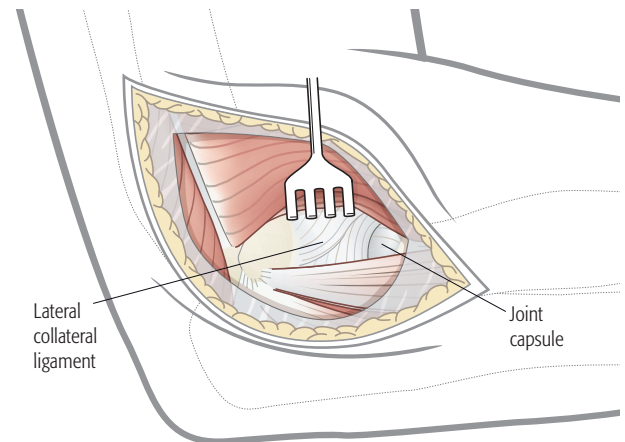


### Identification of the muscle intervals

The interval between the extensor muscle of the fingers and the long extensor muscle of the wrist is identified.



Starting from the anterior aspect of the lateral humeral epicondyle the dissection follows distally the interval between the extensor muscle of the fingers and the long extensor muscle of the wrist. This way the anterolateral aspect of the radiohumeral joint capsule is exposed.

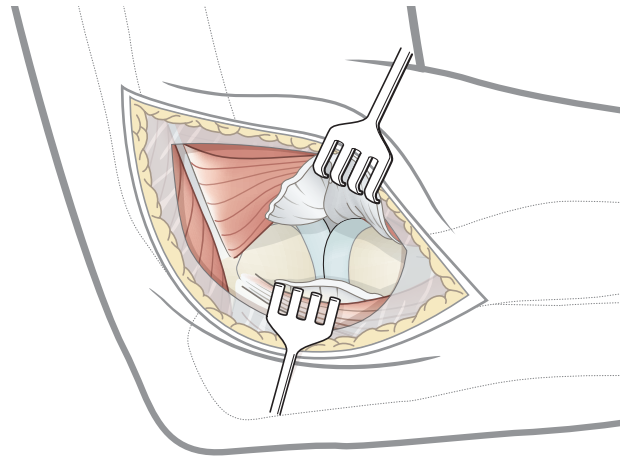






### Opening the joint

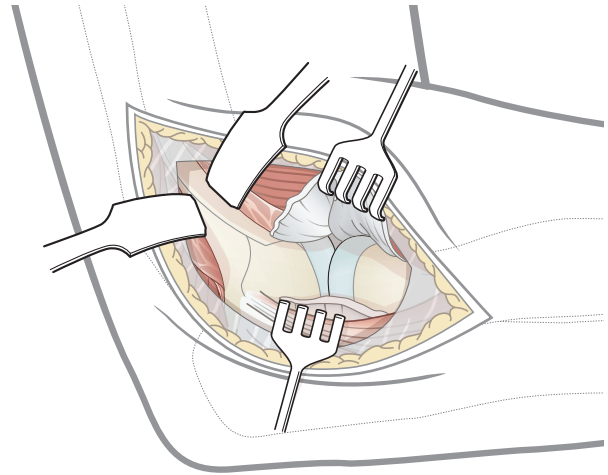
Incise the anterolateral joint capsule longitudinally.



### Further exposure

Subperiosteal reflection of the brachioradialis and extensor carpi radialis longus anteriorly, and the triceps posteriorly will improve joint exposure. Blunt retractors are recommended.

**Note:** Be careful when placing the anterior retractor as the radial nerve is at risk.







## 5.2 Medial approach

### Surgical approach

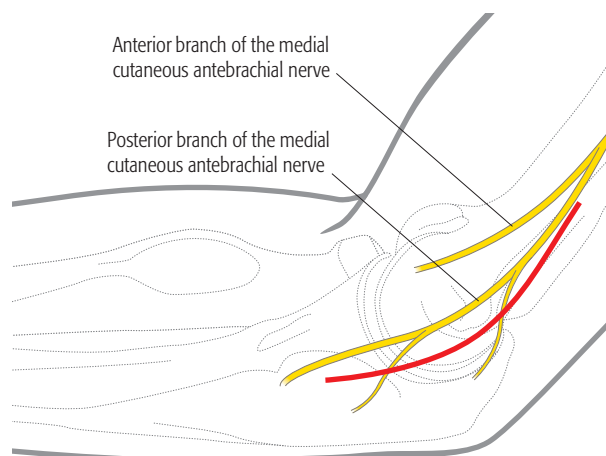
In the medial approach, care must be taken not to compromise the ulnar nerve, or and the posterior branch of the medial cutaneous antebrachial nerve.

### Skin incision

An incision is started 5 cm above the elbow joint, centered over the medial supracondylar ridge and the medial epicondyle, and passes to below the elbow joint.

**Note:** The incision is usually crossed by the posterior branch of the medial cutaneous antebrachial nerve.

Be careful of this nerve branch during the dissection of the subcutaneous tissue; if it is divided, neuroma formation can be troublesome.



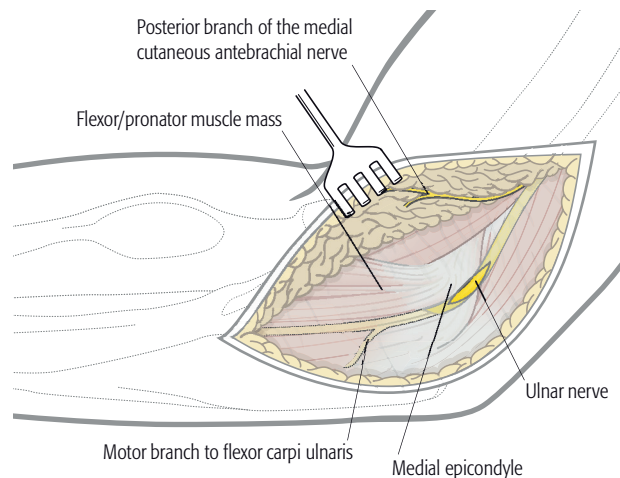


### Identification of the ulnar nerve

Identify the ulnar nerve proximally between the triceps and the medial intermuscular septum, in the groove posterior to the medial epicondyle and distally between two heads of the flexor carpi ulnaris.

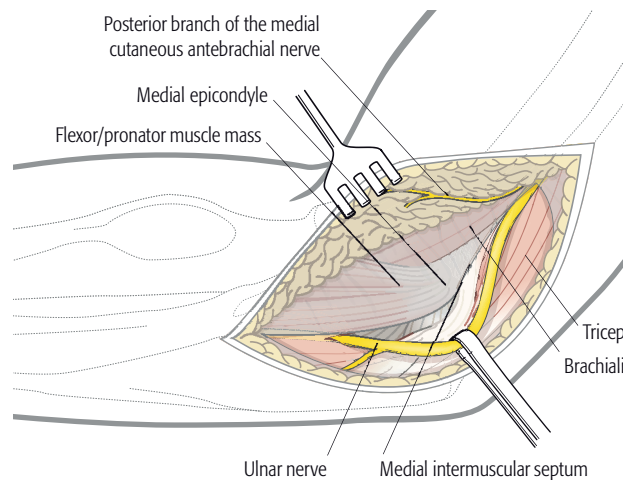
Gently free and protect the ulnar nerve. If anterior transposition of the nerve becomes necessary, be careful to preserve the motor branch to the flexor carpi ulnaris.

It is essential that the OR report should clearly describe how the ulnar nerve has been protected, and the location of the nerve at the end of the operation.



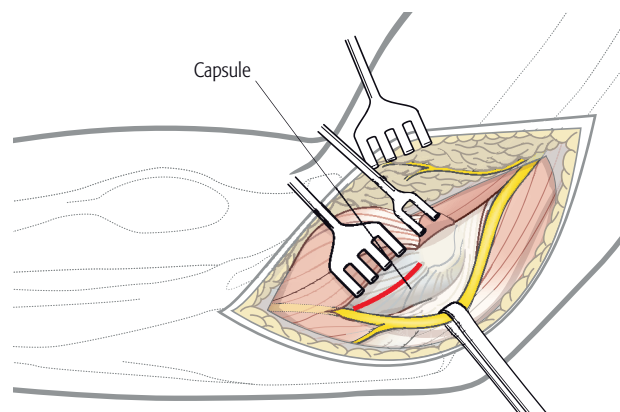
### Deep dissection

The ulnar nerve has been freed and is gently retracted with a vessel loop. Identify the medial supracondylar ridge of the humerus, the medial intermuscular septum, and the origin of the flexor/pronator muscle mass.



Release the medial intermuscular septum from the medial supracondylar ridge of the humerus for a distance of about 5 cm proximally.

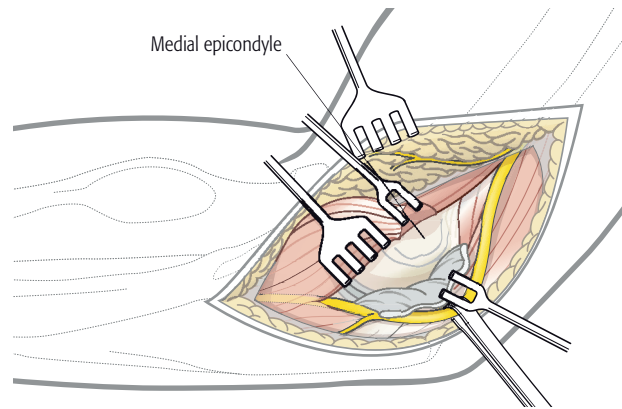
Retract anteriorly the flexor/pronator muscle mass to visualize the joint capsule. The planned capsulotomy is marked in red.





### Opening the joint

Incise the capsule longitudinally and reflect anteriorly and posteriorly from the humerus as necessary.







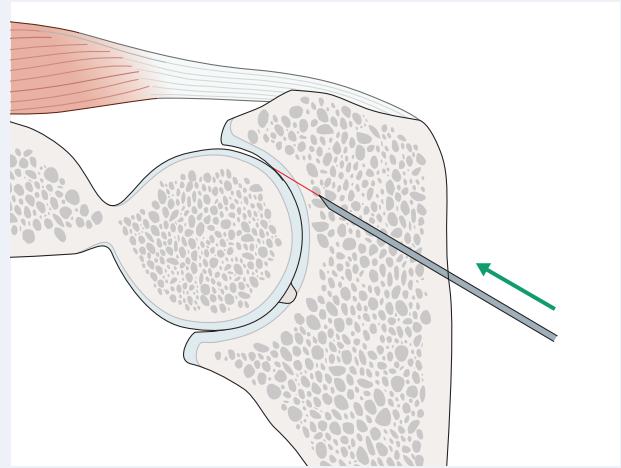
## 5.3 Transolecranon approach

### Surgical approach

This approach involves an osteotomy of the olecranon to allow better access to the elbow joint.

This approach gives excellent access for distal fractures.

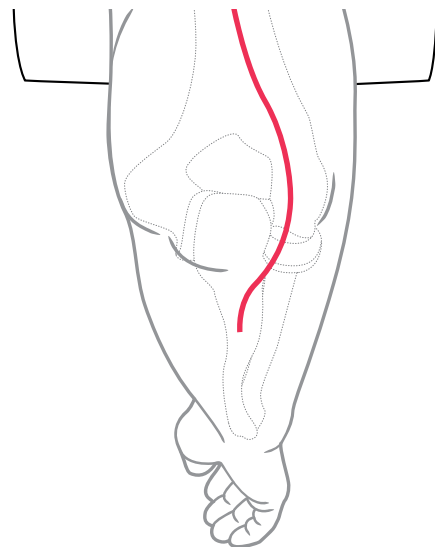
Problems associated with an olecranon osteotomy can be limited by using a careful and meticulous technique for creating and repairing the osteotomy.



### Incision

Make a straight incision beginning level with the junction of the middle and distal thirds of, and centered on, the humeral shaft. Some surgeons make a straight incision, whereas others prefer to curve the incision around the olecranon to the radial side. The incision ends over the ulnar diaphysis.

An ulnar-based subcutaneous flap is developed.



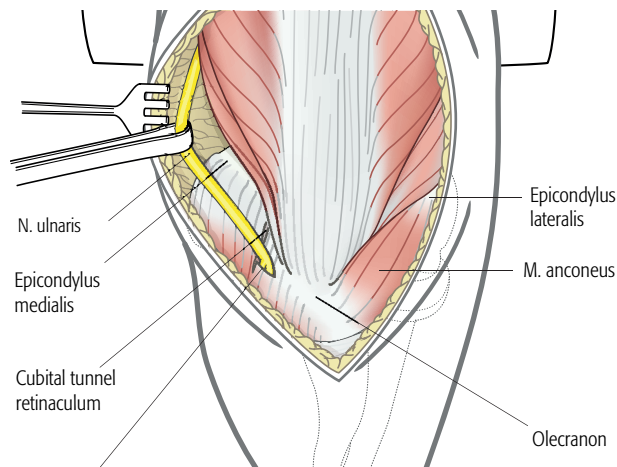
## Ulnar nerve

The ulnar nerve is identified proximally along the medial border of the triceps.

It is then released from the cubital tunnel distally, through the flexor pronator aponeurosis to the level of its first anterior motor branch.

Whenever possible, care should be taken to preserve the perineural vessels.

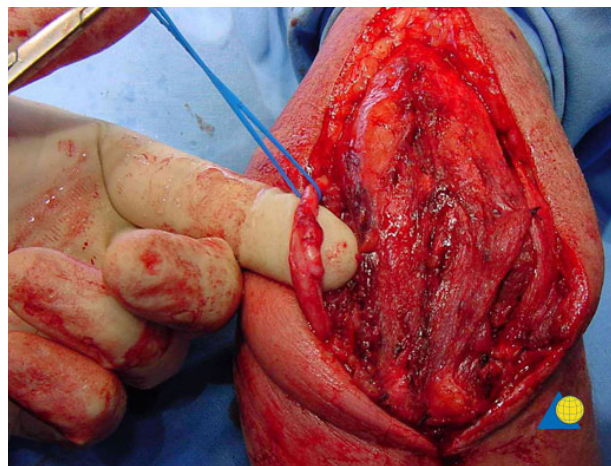
A vessel loop is placed around the ulnar nerve, which is protected throughout the entire procedure.



This intraoperative view shows the ulnar nerve freed and tagged with a vessel loop.

Incise the fascia over the flexor carpi ulnaris muscle at the border of the ulnar bone, as the first step in the preparation of the extensor apparatus flap.

If the ulnar nerve has been mobilized it is essential that the OR report should clearly describe how the ulnar nerve has been protected, and the location of the nerve at the end of the operation.

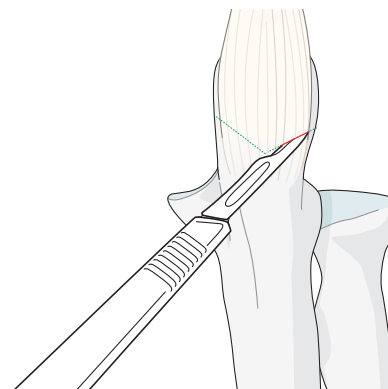


## Preparation for osteotomy

Determine the site of the osteotomy by incising either the medial capsule, after retracting the ulnar nerve, or the lateral capsule, after elevating part of the anconeus muscle and finding the center of the trochlear notch.

Clear the bone with a small elevator at the site of the planned osteotomy.

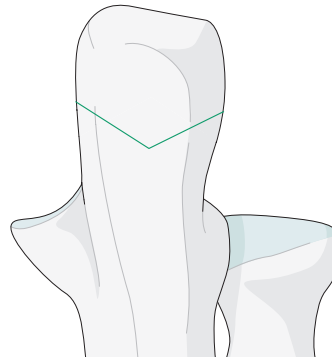
Mark a chevron osteotomy with a distal apex.





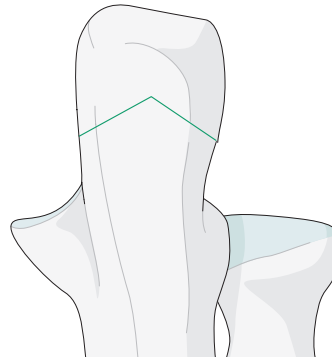


Chevron osteotomy with the apex distal



**Alternative: Chevron osteotomy with the apex proximal (reversed chevron)**

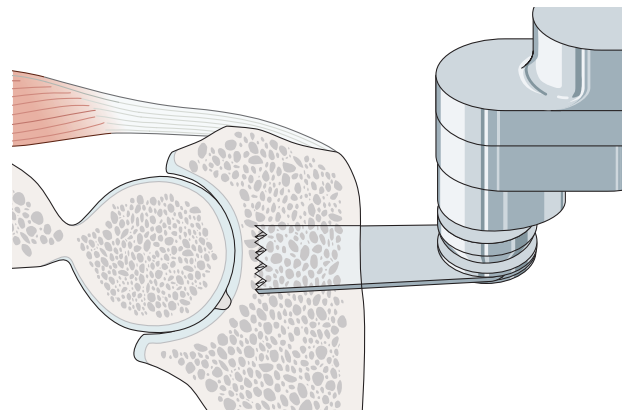
Sometimes the fracture configuration is such that a reversed chevron osteotomy is preferable.



**Osteotomy**

**Saw**

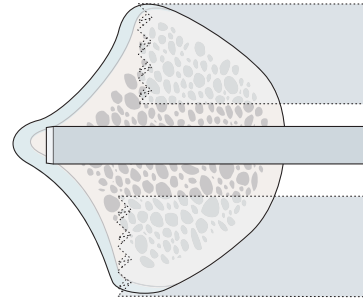
Because of the shape of the olecranon, use a fine oscillating saw to divide only up to three quarters of the depth of the bone.





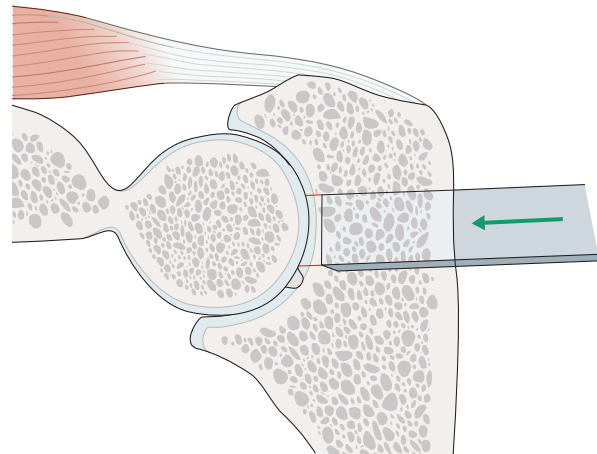
### Chisel

Use a chisel on the last part of the bone, but only just short of the subchondral bone. Remember that the central ridge of the olecranon, which is very strong, will need to be divided deeper, using a very narrow bladed chisel.



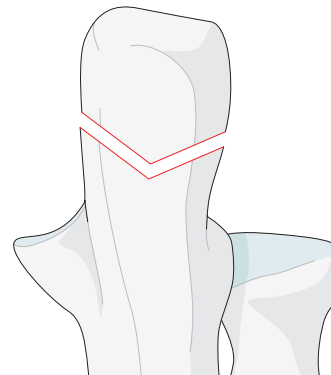
The subchondral bone is then fractured by levering the osteotomy apart.

**Note:** Some surgeons prefer to perform the entire osteotomy with chisels, rather than with a power saw.



### Chevron shape

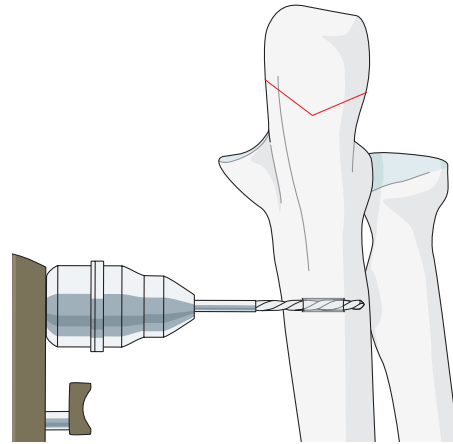
The chevron osteotomy is preferred to give a better and more stable bony contact during the repair of the olecranon reduction. The larger surface improves bone healing, and the shape improves rotational stability.



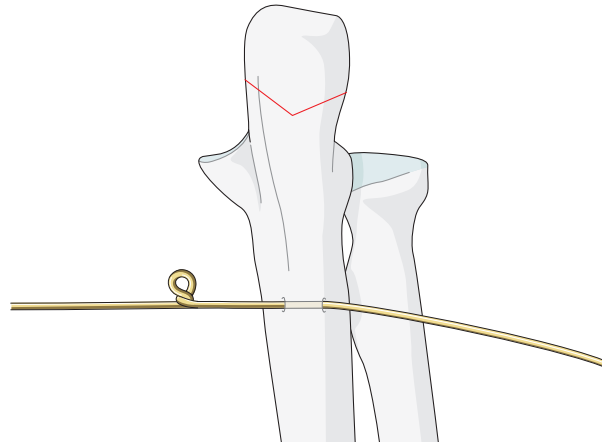


### Reduction and fixation of the olecranon

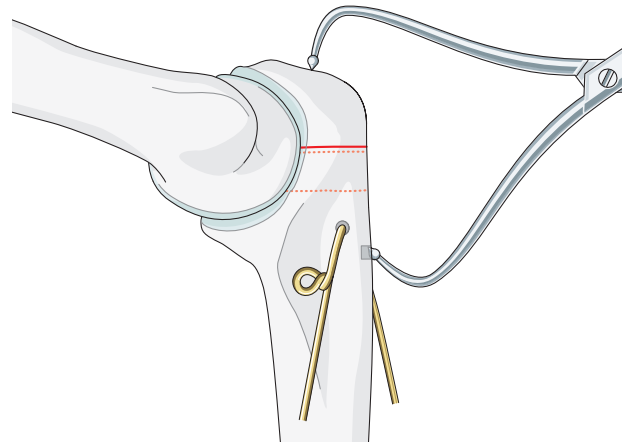
Using a 2.5 mm drill, make a coronal hole in the proximal ulna, from ulnar to radial side, to pass the figure-of-eight wire.



Prepare a 0.8 mm wire by making a loop approximately one third along its length. Insert the shorter segment of the wire through this drill hole.

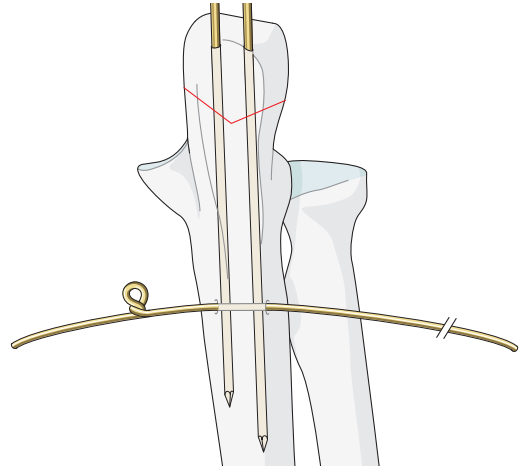


Reduce the olecranon osteotomy with pointed reduction forceps.

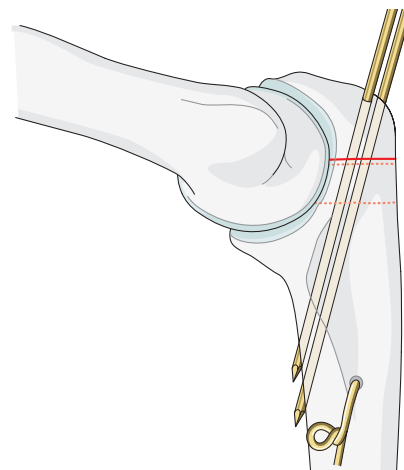




Use the figure-of-eight tension band wiring technique to obtain stable fixation. Two K-wires are drilled parallel across the osteotomy.

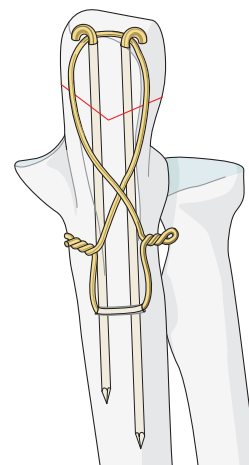


The K-wires can be directed down the shaft of the ulna, or alternatively aimed anterior so that they engage the anterior ulnar cortex, just distal to the coronoid process: this may help to limit the potential for wire migration.



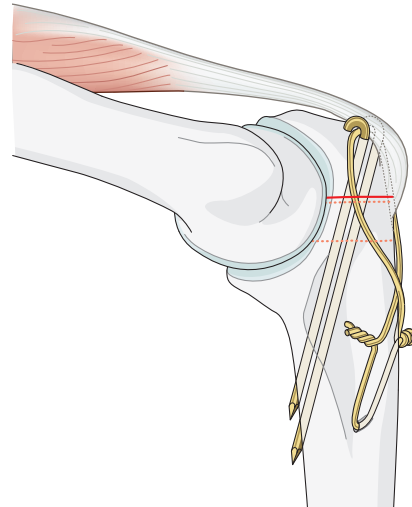
The wire loop has to go underneath the triceps tendon.

Double twist the wire loop to obtain equal tension on both sides. The cut wire loops are then impacted firmly onto the bony cortex of the olecranon, being sure to bury them beneath the triceps tendon.





The image shows the completed osteosynthesis of the olecranon.



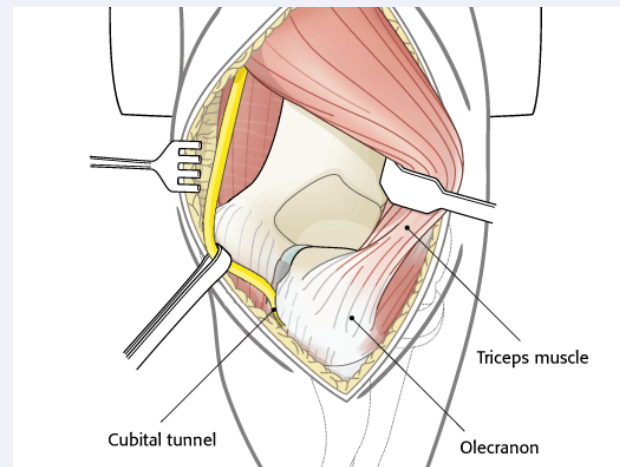




## 5.4 Posterior triceps-on (Alonso-Llames) approach to the distal humerus

### Surgical approach

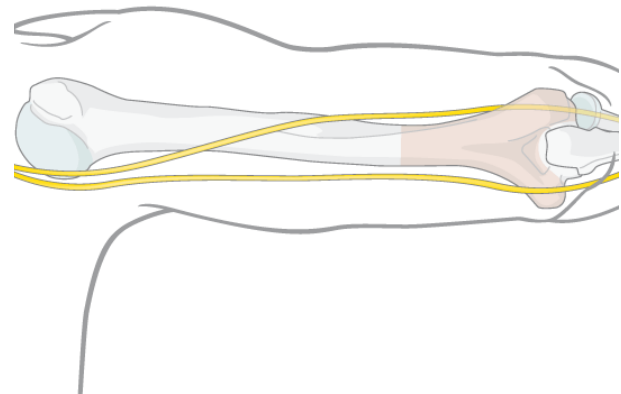
For some extraarticular and simple articular fractures of the distal humerus, the posterior triceps-on approach, which leaves the triceps insertion intact, can provide adequate exposure for reduction and fixation. Posterior triceps-on (Alonso-Llames) approach to the distal humerus



### General considerations

For some extraarticular and simple articular fractures of the distal humerus, an approach that leaves the triceps insertion intact can provide adequate exposure for reduction and fixation.

This exposure is very similar to the transolecranon, but without the osteotomy. The triceps is elevated off the posterior humerus, but its insertion is not disturbed.

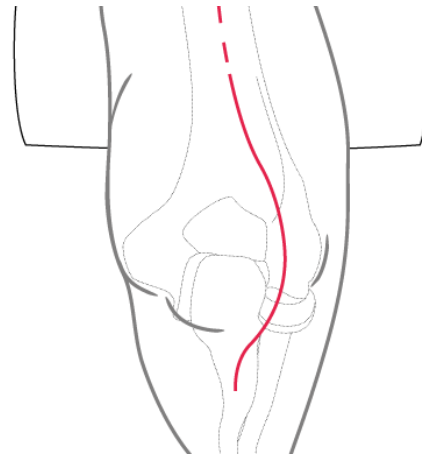




### Skin incision

Make a straight incision beginning level with the junction of the middle and distal thirds of, and centered on, the humeral shaft. Some surgeons make a straight incision, whereas others prefer to curve the incision around the olecranon to the radial side. The incision ends over the ulnar diaphysis.

An ulnar-based subcutaneous flap is developed.

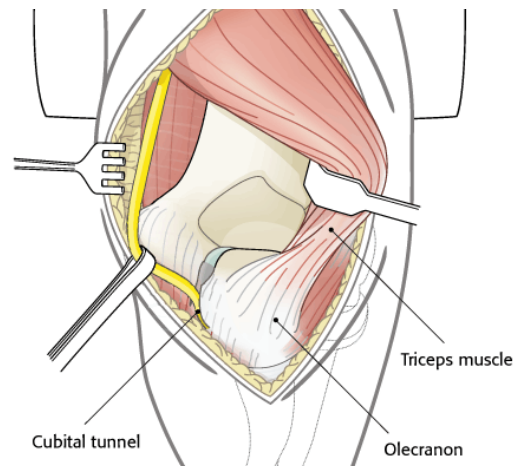


### Ulnar window

As a first step, the ulnar nerve is isolated and protected with a vessel loop.

Proximally, the ulnar nerve is followed along its course on the medial intermuscular septum, and the triceps muscle is mobilized radially.

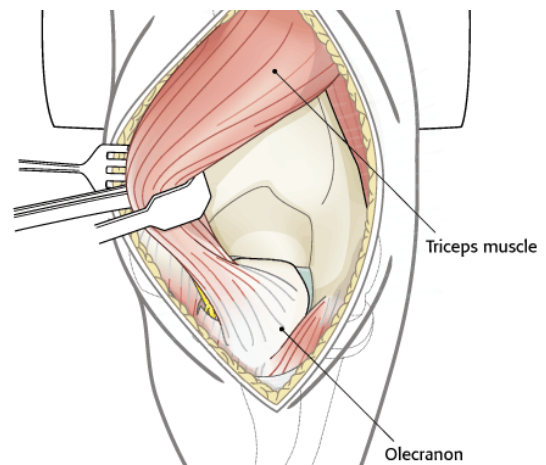
If the ulnar nerve has been mobilized it is essential that the OR report should clearly describe how the ulnar nerve has been protected, and the location of the nerve at the end of the operation.



### Radial window

The triceps fascia is split, and the muscle is mobilized from the lateral intermuscular septum and humerus towards the ulnar side.

Distally, the anconeus muscle is detached from the radial column as much as is necessary.

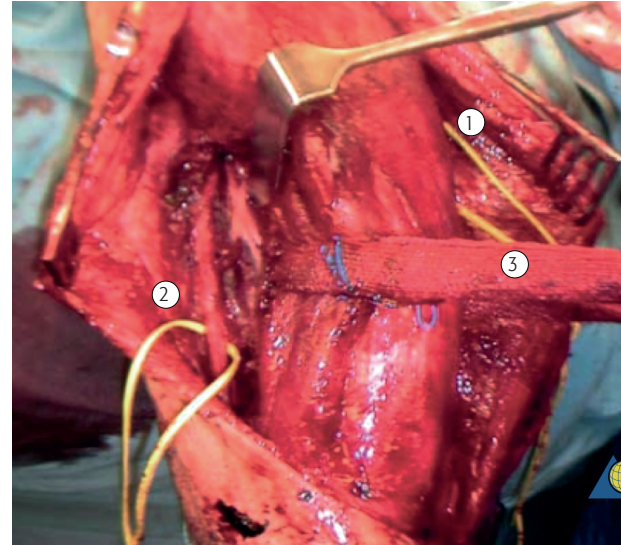




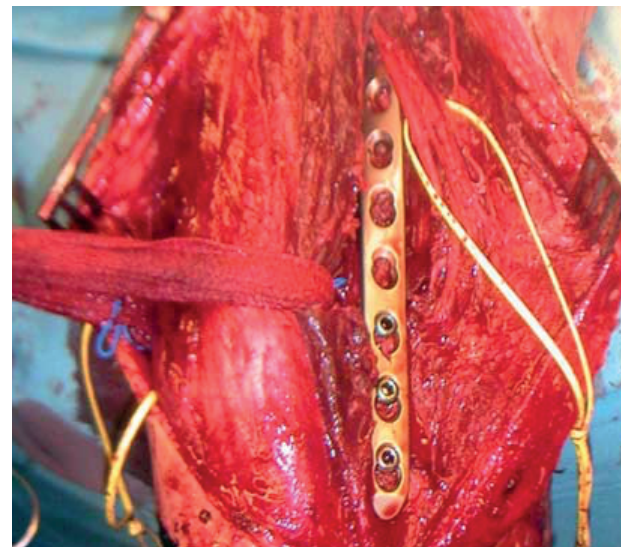


In the case shown here, going up into the diaphysis, the radial and ulnar nerves were identified and held with vessel loops (**1** and **2**).

The entire triceps muscle is isolated with a gauze wrap (**3**). This permits the whole triceps muscle to be moved towards either the lateral or medial side, in order to get access to the humerus ("triceps flip").



A contoured posterolateral plate has been placed and fixed to the distal humeral fragment.

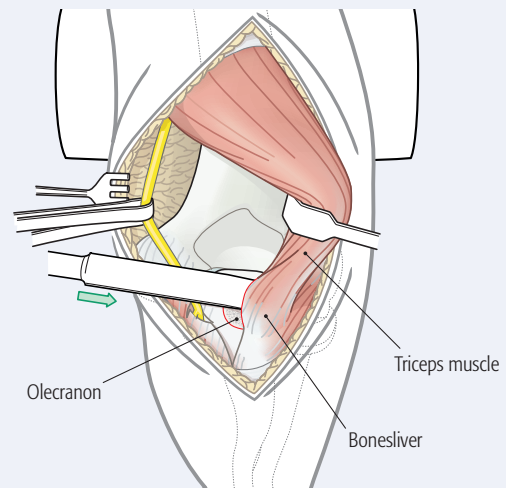




## 5.5 Triceps-elevating approach

### Surgical approach

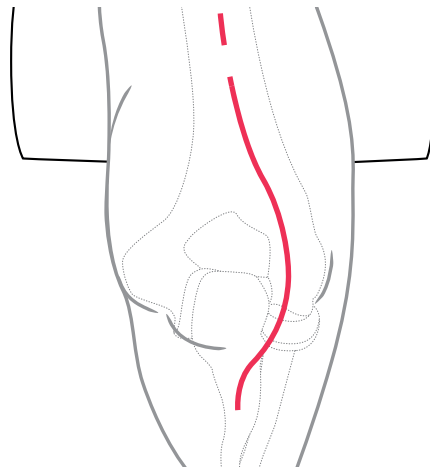
The triceps elevating approach offers an extensile posterior exposure to the elbow, which allows for an effective restoration of the triceps function.



### Incision

Make a straight incision, beginning level with the junction of the middle and distal thirds of, and centered on, the humeral shaft. Some surgeons make a straight incision, whereas others prefer to curve the incision around the olecranon to the radial side. The incision ends over the ulnar diaphysis.

An ulnar-based subcutaneous flap is developed.





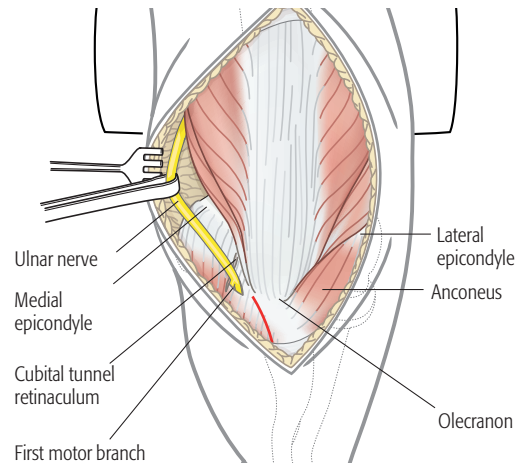
### Ulnar nerve

The ulnar nerve is identified proximally along the medial border of the triceps.

It is then released from the cubital tunnel distally, through the flexor pronator aponeurosis to the level of its first anterior motor branch.

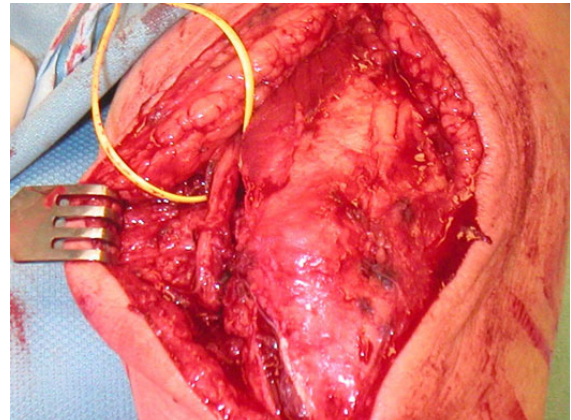
Whenever possible, care should be taken to preserve the perineural vessels.

A vessel loop is placed around the ulnar nerve, which is protected throughout the entire procedure.



This intraoperative view shows the ulnar nerve freed and tagged with a vessel loop.

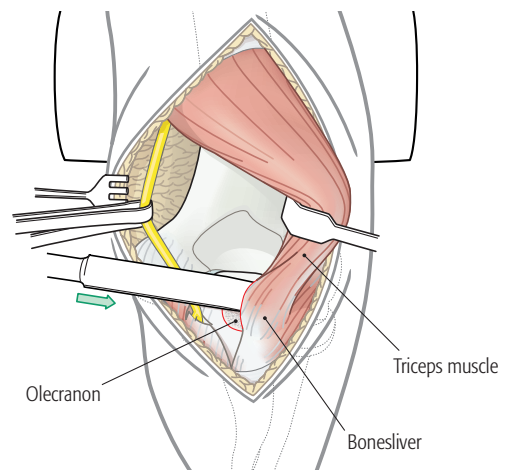
Incise the fascia over the flexor carpi ulnaris muscle at the border of the ulnar bone, as the first step in the preparation of the extensor apparatus flap.



### Extensor apparatus

The fascia is detached subperiosteally from the ulna towards the radial side.

At the level of the olecranon the extensor apparatus is detached together with a sliver of bone using a fine chisel.



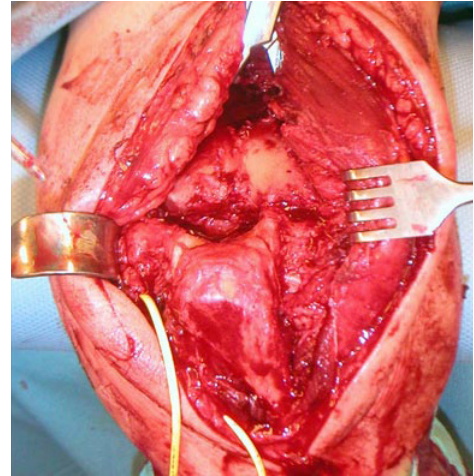


Proximal to the olecranon the posterior capsule is incised. At the level of the humerus the extensor muscles are freed from the bone. Now the entire extensor apparatus flap can be retracted to the radial side.

Distally the flap is based on the anconeus muscle.

To enhance visualization of the articular surface, the elbow should be flexed beyond 100°.

Optionally, the tip of the olecranon can be removed.

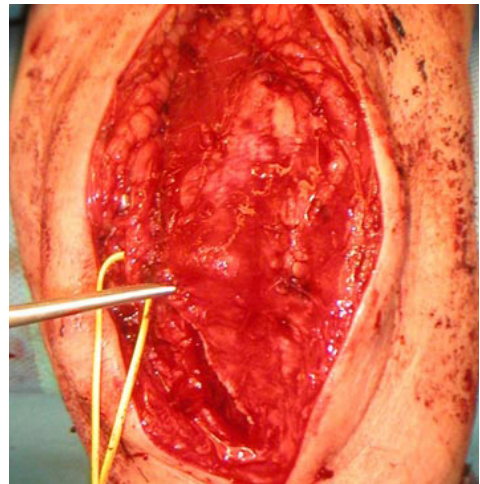


### Closure

For closure, the extensor apparatus is pulled into place using a Kocher clamp.

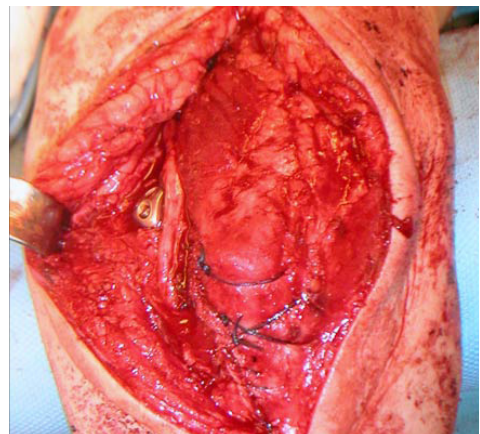
Some surgeons place the ulnar nerve back in the cubital tunnel, whereas other surgeons perform an anterior subcutaneous transposition.

It is essential that the OR report should clearly describe how the ulnar nerve has been protected, and the location of the nerve at the end of the operation.



The bone sliver is reattached to the olecranon with transosseous sutures.

Distally, the incision of the flexor carpi ulnaris fascia is closed.







## 5.6 Safe zones

### Surgical approach

Inserting percutaneous instrumentation through safe zones reduces the risk of damage to neurovascular structures.

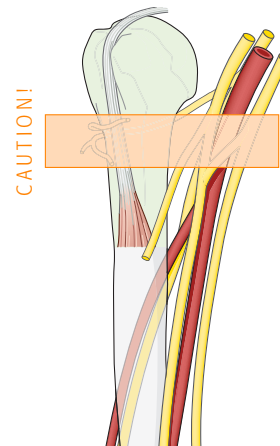
### Proximal third of the humerus

Pins or screws are inserted from a lateral (alternatively from an anterolateral or a posterolateral) direction through the deltoid muscle.

Avoid damage to the long head of biceps tendon.

The tips of the pins should just perforate the far cortex. If inserted too deeply, the tips can injure the medial neurovascular bundle.

Damage to the axillary nerve must be avoided. This nerve runs dorsolaterally around the humeral metaphysis, about 5 cm below the greater tuberosity.



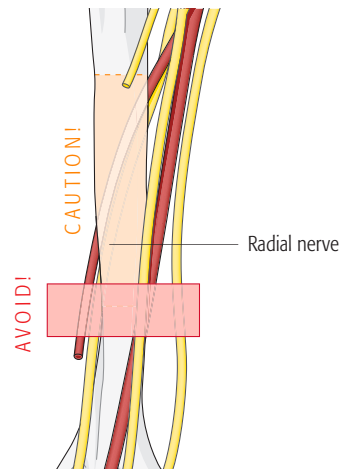




### No safe zone in the middle third of the humerus

Avoid pin placement in the middle third as the radial nerve, which is in close relationship with the dorsal diaphyseal cortex, can be damaged.

If it is felt to be essential to place a pin in the middle third the radial nerve needs to be identified and protected.

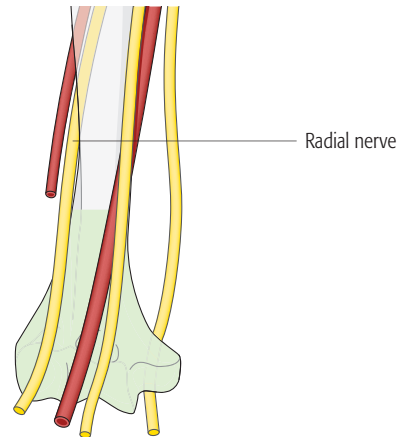


### Distal third of the humerus

Pins are inserted from a posterior (alternatively from a posterolateral or a posteromedial) direction, through the triceps muscle.

Avoid penetration of the olecranon fossa.

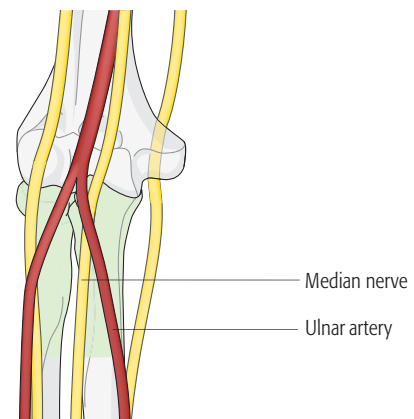
The tips of the pins or screws should just perforate the far cortex. Insertion too deeply can damage the median nerve and/or the brachial artery.



### Proximal forearm

Pins are inserted from a posterior aspect directly into the proximal third of the ulnardiaphysis. It is an easily recognizable and palpable bone. Avoid insertion into the radius, in order not to impair rotational motion of the forearm.

The tips of the pins or screws should just perforate the far cortex. Insertion too deep can damage the median nerve and/or ulnar artery.



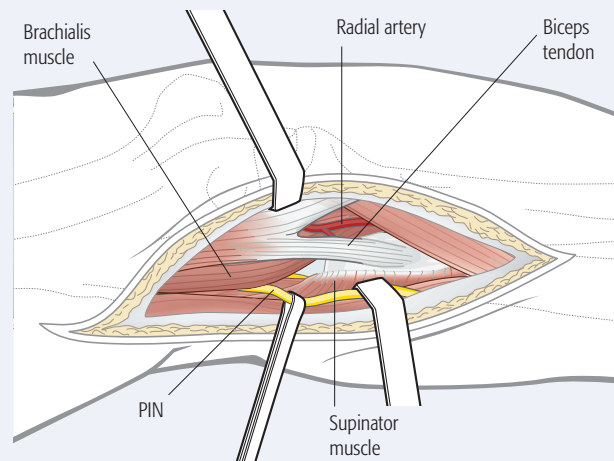


## 5.7 Anterior approach

### Surgical approach

The anterior approach can be used to access the bicipital tuberosity of the radius, the coronoid process, and the capitellum and trochlea.

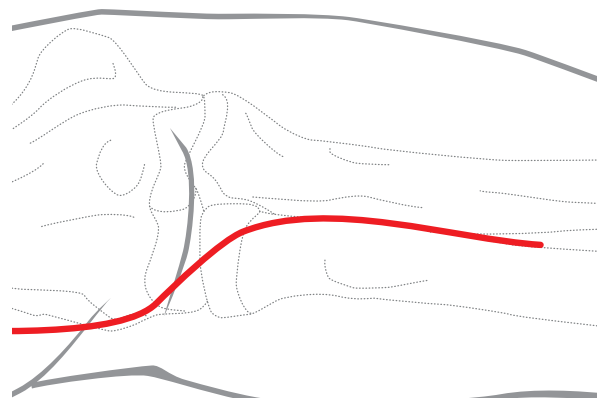
Anterior approach to the capitellum and trochlea



### Skin incision

A curved incision over the anterior aspect of the elbow is performed, starting 5 cm above the flexion crease on the lateral side of the biceps.

Curve the incision over the front of the elbow. It ends on the medial border of the brachioradialis.



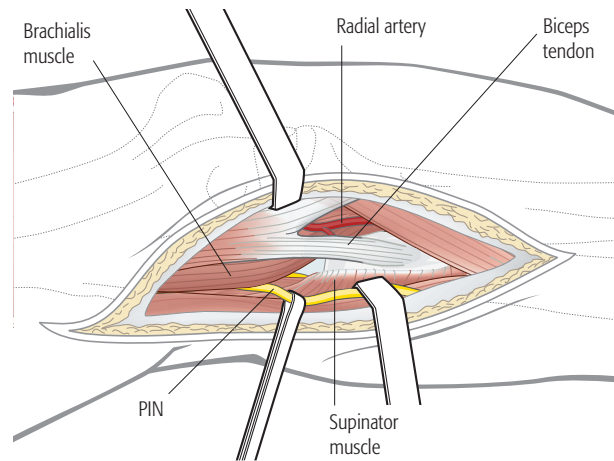


### Surgical dissection

Identify and protect the posterior interosseous branch (PIN) of the radial nerve at the lateral margin of the brachialis muscle. Carefully follow this branch into the supinator muscle.

Split the fascia and ligate the recurrent radial artery.

Further deep dissection exposes the bicipital tuberosity of the radius. Reflect the supinator carefully, protecting the PIN, to display the tuberosity.



### Closure

The wound is closed in layers.