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# 6 Proximal forearm

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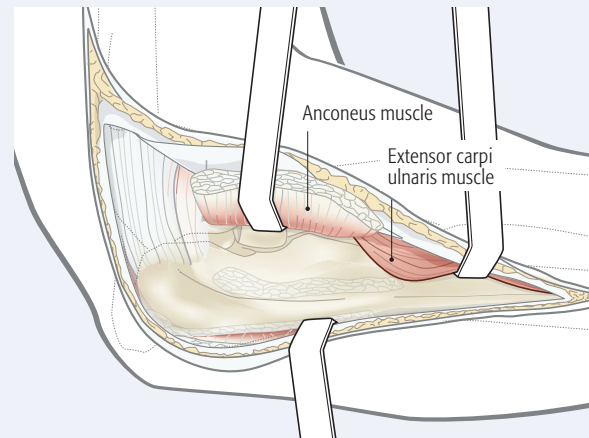




## 6.1 Posterolateral approach to the proximal olecranon

### Surgical approach

A straight midline incision provides direct subcutaneous access to the proximal olecranon. Skin and subcutaneous flaps can be developed to access both medial and lateral approaches described below. Laterally, the midline incision can be developed submuscularly as the Boyd approach, gaining exposure for ulnar shaft and radial head fractures.



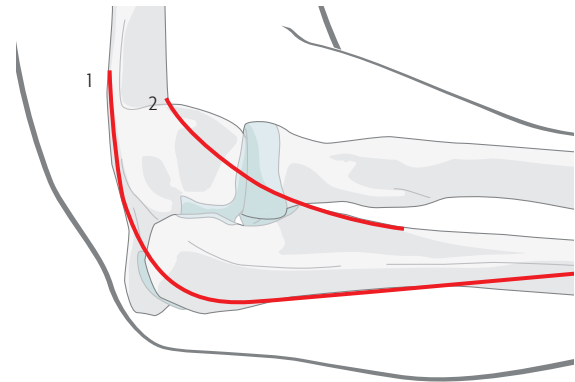
### Skin incision

A straight midline posterior incision can be used. The advantage of this is that it is extensile and offers the possibility to go both medial and lateral. Medial and lateral skin flaps can be created to access other muscle intervals to treat fractures of the radial head or coronoid and collateral ligament avulsions.

A shorter, more lateral incision is also possible but will not allow exposure of the medial side of the elbow.

The Boyd approach can be developed through lateral submuscular dissection.

For the posterior incision (**option 1**), start the incision a few centimeters proximal to the tip of the olecranon. Some surgeons like to curve the incision slightly medially or laterally around the tip of the olecranon (to prevent scar irritation when leaning on the elbow) while others make a straight incision.



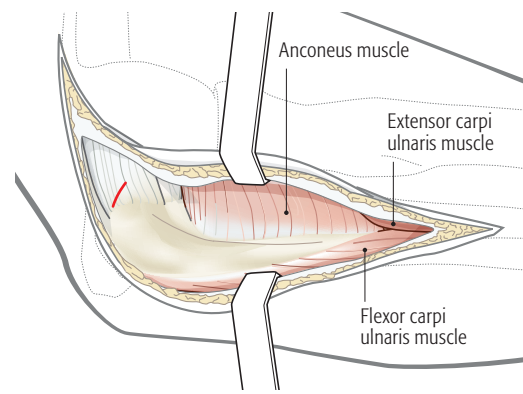


### Skin incision cont.

The more lateral incision (**option 2**) runs slightly more lateral and crosses directly over the lateral epicondyle. Further dissection is the same independently on the skin incision. To illustrate the procedure we will show the more commonly used posterior midline incision.

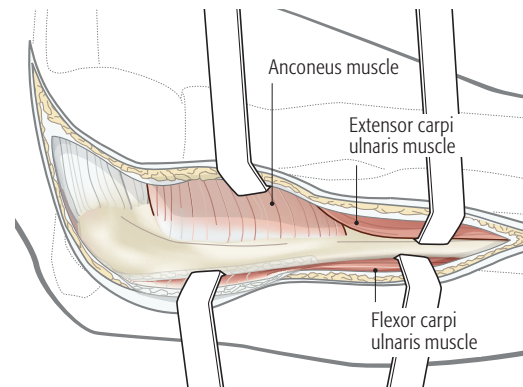
### Posterior surface of olecranon

If a plate placed on the posterior surface of the bone curves around the tip of the olecranon, one can incise the triceps so that the plate lies directly on bone or place the plate directly on top of the triceps insertion (advantageous for some fractures with fragmentation of the olecranon). Detach as little periosteum and muscle as possible. Articular fractures are visualized by mobilizing the proximal fragment and triceps.



### Posterior surface of the posterior ulna

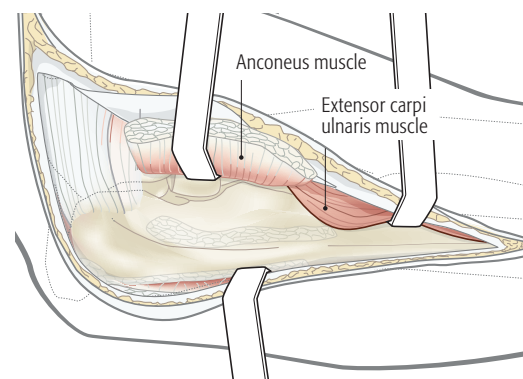
A plate applied to the posterior surface of the proximal ulna will lie on the apex of the ulnar diaphysis. It is not necessary to elevate muscle or periosteum to apply the plate on the apex of the diaphysis. One need only split the interval between the flexor carpi ulnaris and extensor carpi ulnaris.



### Radial head exposure

Now that the ulna exposure is completed, the radial head can easily be exposed as well. Often the deep dissection has been done by the initial trauma making identification of the exact anatomic plane difficult. Rather than identifying the anatomical plane one can use the traumatic soft tissue injury as long as neurovascular structures are spared.

**Note:** Proponents of a dual deep dissection (one for the proximal ulna and one for the proximal radius) argue that this has a decreased risk for synostosis formation.

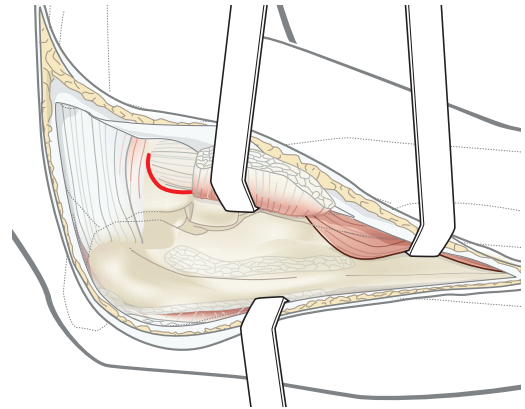






### Variation with osteotomy of the lateral humeral epicondyle

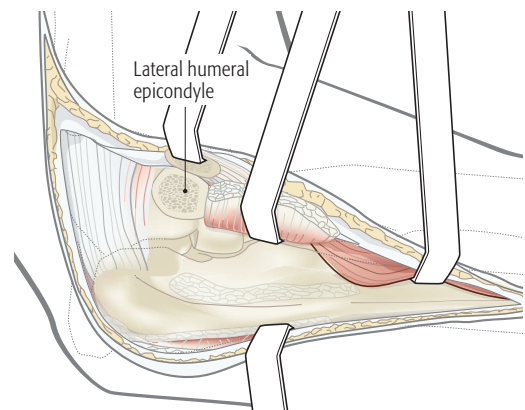
A variation for lateral exposure with preservation of collateral ligaments and extensor tendon origin involves osteotomy of the lateral humeral epicondyle.



### Access to the proximal radius and ulna

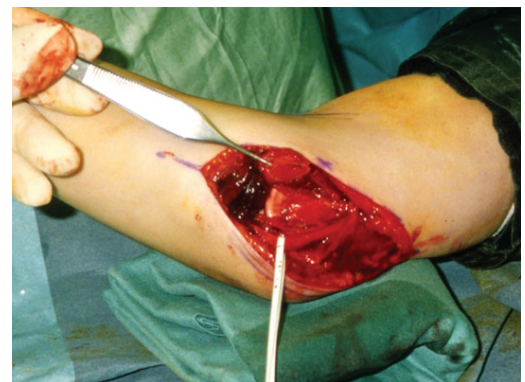
**Fig 3.1-6b** The soft tissues and osteotomized lateral epicondyle are reflected anteriorly to provide access to the proximal radius and ulna.

Repair after this approach requires refixation of the lateral epicondyle. The necessary screw hole can be predrilled before making the osteotomy.



### Variation with osteotomy of the medial humeral epicondyle

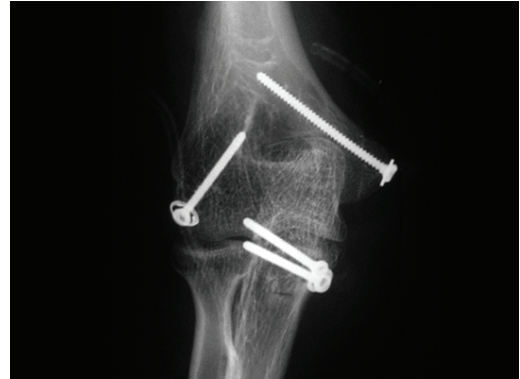
A variation for medial exposure with preservation of the medial collateral ligament and common flexor origin involves osteotomy of the medial humeral epicondyle. The soft tissues and osteotomized medial epicondyle are reflected distally to provide access to the medial elbow joint and proximal ulna.





### Fixation

Repair after this approach requires replacement and fixation of the medial epicondyle. The screw hole can be drilled before the osteotomy.

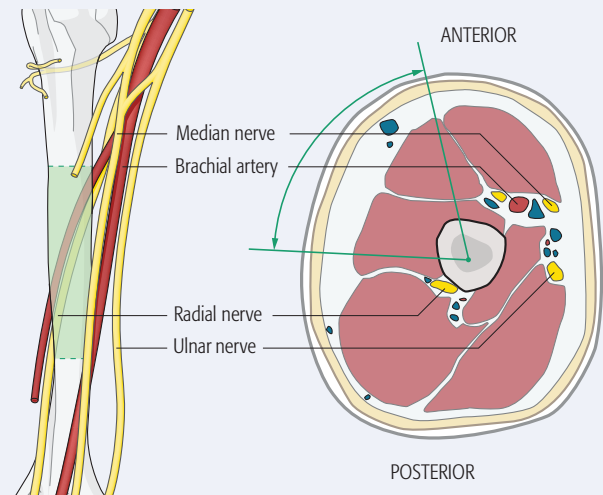




## 6.2 Safe zones of the forearm

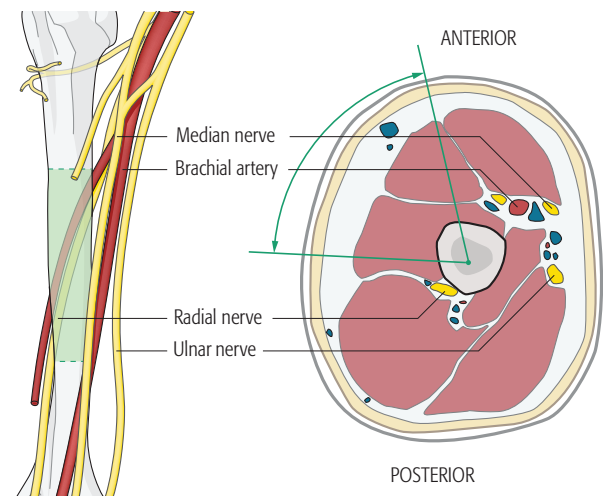
### Safe zones

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



### Safe zone in the humerus distal third

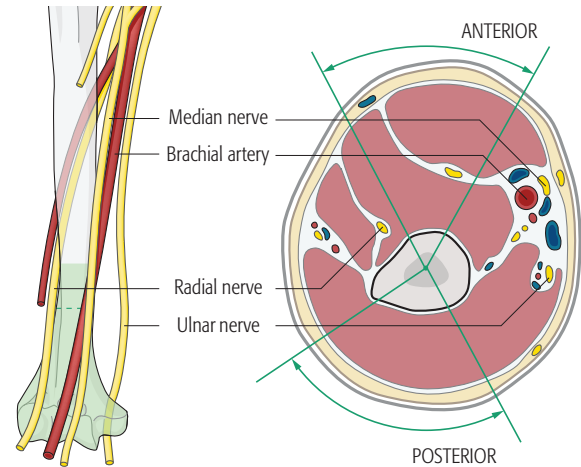
Schanz screws are inserted from an anterolateral or posterolateral direction through the triceps muscle. Avoid penetration of the olecranon fossa. Due to the risk of nerve or vascular injury, the tips of the Schanz screws should just perforate the far cortex.





### Safe zone in the humerus middle third

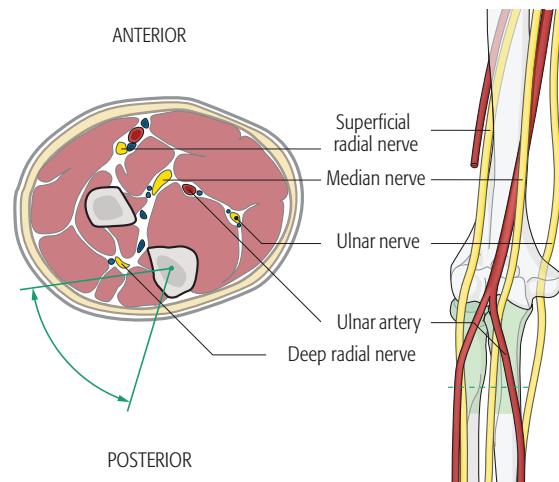
In the proximal third of the middle shaft, Schanz screws can be inserted anterolaterally. Avoid Schanz screw placement distal to this point as the radial nerve is at risk.



### Safe zone in the proximal forearm

With the forearm in neutral position, Schanz screws are inserted into the lateral or posterolateral part of the proximal or middle third of the ulna.

It is an easily recognizable and palpable bone. Carefully check pronation and supination after insertion to make sure the Schanz screw does not affect the radius.

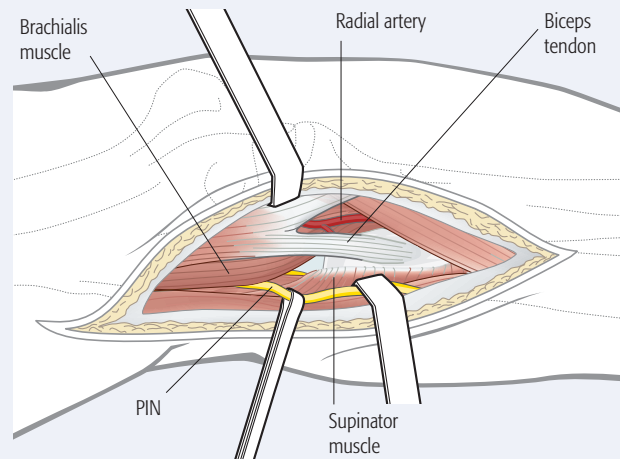




## 6.3 Anterior Approach to the radius neck

### Surgical approach

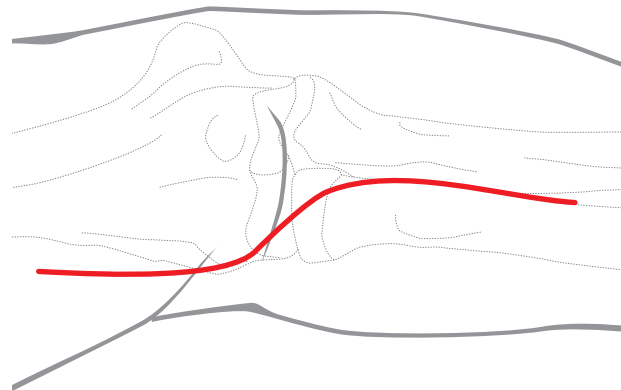
The anterior approach can be used to access the bicipital tuberosity of the radius and/or the radial neck/metaphysis.



### 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.



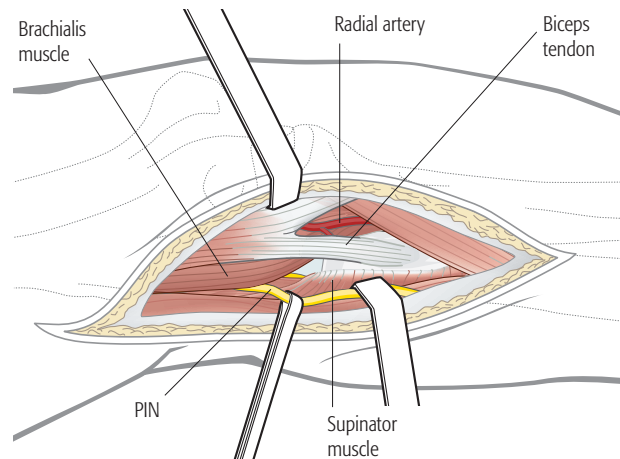


### Surgical dissection

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.

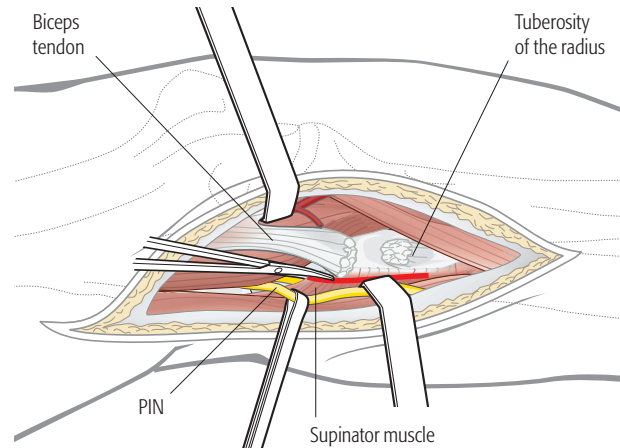
Split the fascia and ligate the recurrent radial artery.

Further deep dissection exposes the bicipital tuberosity of the radius or the radial neck.



### For reattachment of the biceps tendon

If this approach is used for reattachment of the biceps tendon, release and reflect the supinator carefully, protecting the PIN, display the tuberosity by full supination.



### Closure

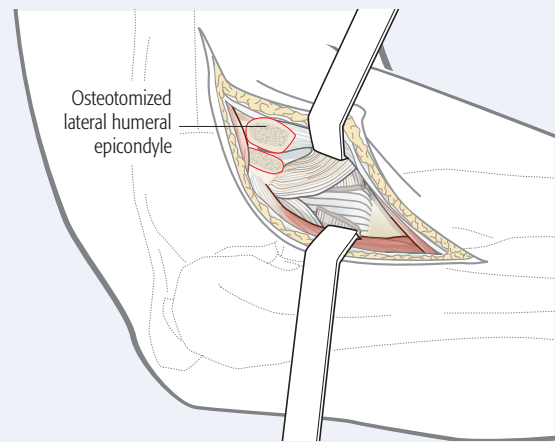
The wound is closed in layers.



## 6.4 Lateral Approach to the radial head and the tip of the coronoid

### Surgical approach

The lateral Kocher/Kaplan approach can be used to access the radial head and the tip of the coronoid.

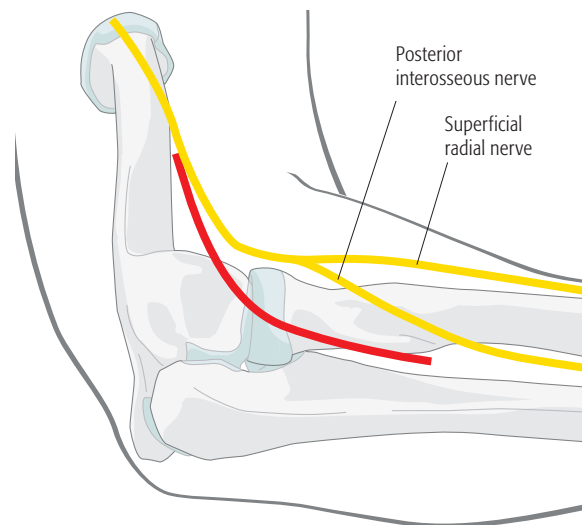


### Skin incision

Either a posterior skin incision with a lateral skin flap or a lateral skin incision can be used.

For a lateral skin incision, place the elbow at 90 degrees and try to pinch the lateral condyle (easier in thin patients). Make a straight skin incision directly over the middle of the lateral condyle. Start with a small incision (6-8 cm or so) and extend proximal or distal as needed.

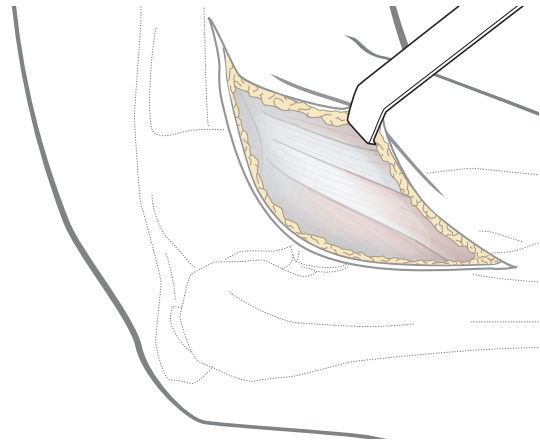
**Note:** The posterior interosseous nerve, within the supinator muscle, crosses the posterior radius, from anteriorly, three finger-breadths distal to the radial head. It must be protected during this approach.





### Superficial surgical dissection

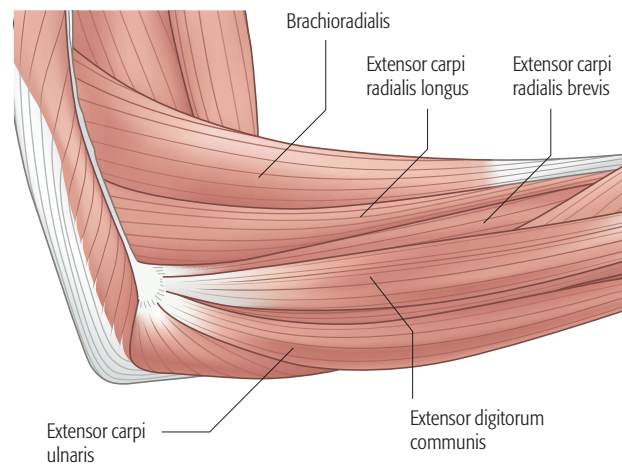
Incise the subcutaneous tissue in line with the incision and raise flaps to expose the fascia over the muscles.



### Kaplan interval

It can be difficult to determine exact muscle intervals. When we are operating on the radial head, there is usually associated injury to the lateral collateral ligament and common digit and wrist muscle origins. Along with this damage there is usually a rent in the fascia that can be opened and extended distally. This usually lies in the interval between the extensor carpi radialis brevis and extensor digitorum communis (Kaplan interval). The associated ligament and muscle injury will make the rest of the exposure very easy.

The Kaplan interval can also be identified by elevating the origin of the extensor carpi radialis brevis from the supracondylar ridge of the distal humerus, elevating the brachioradialis from the anterior humerus, then continuing distally until the joint is entered and the capitellum is visualized. Elevating these muscles is necessary to exposure the coronoid from the lateral side. Split the common wrist and digital extensor musculature at the point that divides the capitellum in half anterior/posterior.

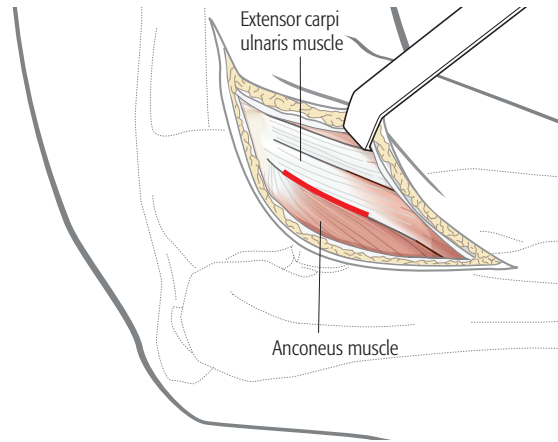






### Kocher interval

The interval between the anconeus and extensor carpi ulnaris (Kocher interval) is relatively more posterior and thus risks injuring the lateral collateral ligament complex.

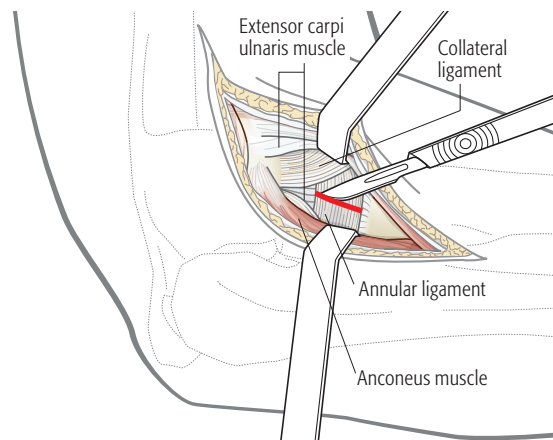


### Avoiding damage to radial nerve

- 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.
- No retractor should be placed around the radial neck.

### Deep surgical dissection

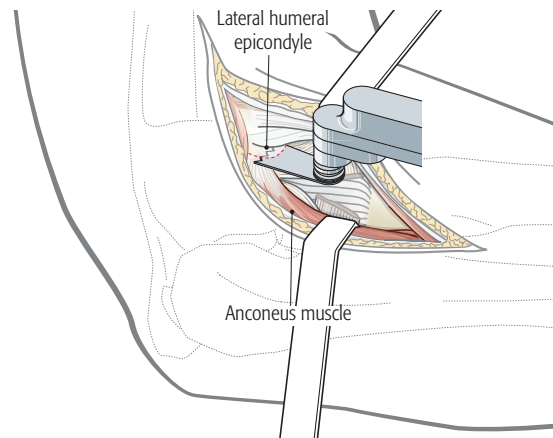
The following illustrations will show the deep dissection for the Kocher interval. The annular ligament is divided in line with the muscle interval.





### Osteotomy of lateral epicondyle

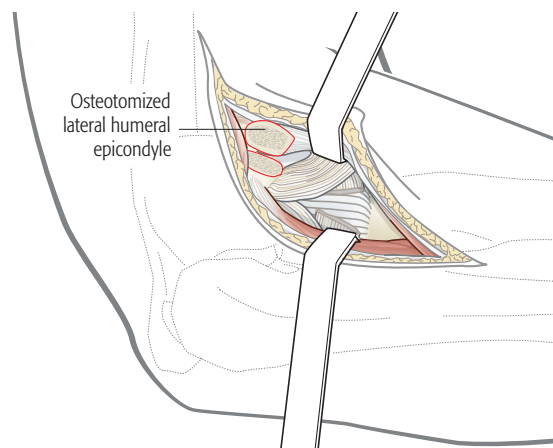
If the lateral collateral ligament is intact and better exposure of the radial head and neck are desired, one can consider osteotomy of the lateral humeral epicondyle. The osteotomy line in the illustration is marked in red.



### Access to the proximal radius and ulna

The soft tissues and osteotomized lateral epicondyle are reflected anteriorly to provide access to the proximal radius and ulna.

Screw fixation of the osteotomy can be difficult because the fragment is small and metaphyseal. A tension band wire is an alternative, using the muscle origin as a more reliable point of fixation.



### Closure

The wound is closed in layers.

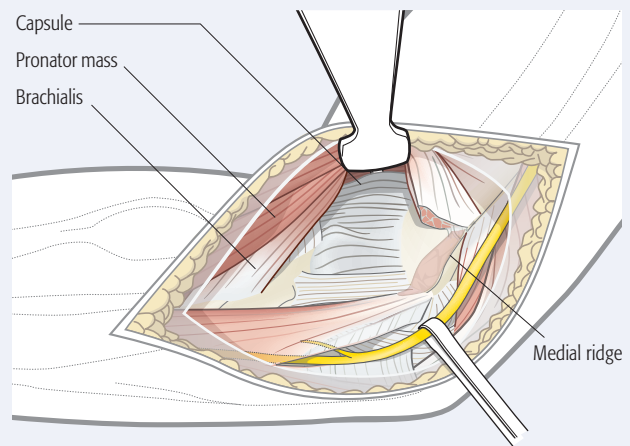




## 6.5 Medial “over the top” approach

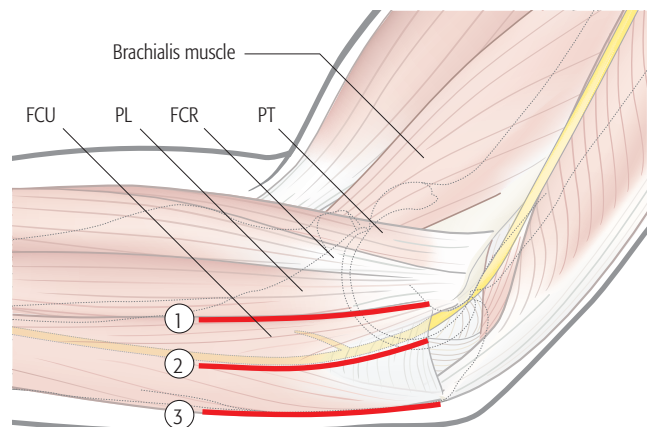
### Surgical approach

The Hotchkiss “over the top” approach is the most anterior of the medial approaches and provides good access to the tip of the coronoid process and the whole anterior elbow joint.



### Medial approaches

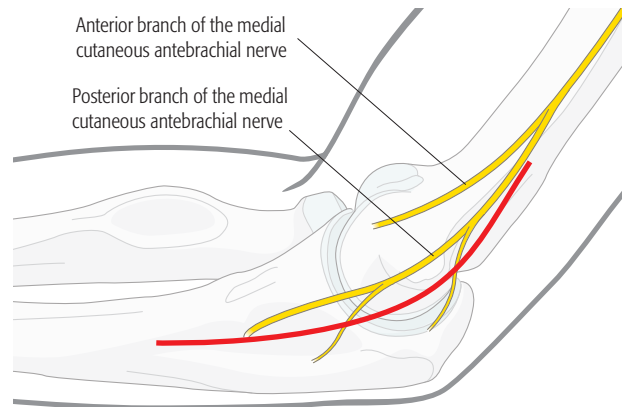
The interval that splits the flexor-pronator mass and elevates the anterior part (pronator teres (PT), flexor carpi radialis (FCR), and palmaris longus (PL)) along with brachialis from the anterior elbow capsule gives good access to the anterior elbow capsule and the tip of the olecranon also known as the Hotchkiss “over the top” approach (**1**). The access to the medial facet of the coronoid is limited and there is also poor access to the base of the coronoid. For access to the medial facet, use the interval where the ulnar nerve lies between the heads of the flexor carpi ulnaris (FCU split; **2**). For access to the base consider elevating the entire flexor-pronator mass from posterior to anterior (Taylor and Scham; **3**). In the following the Hotchkiss over the top approach is described.





### Skin incision

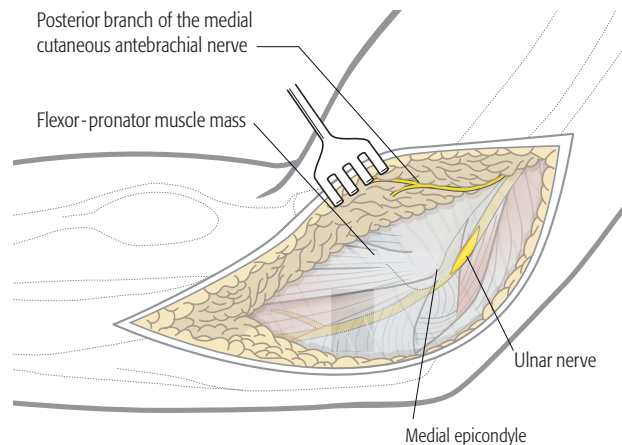
The skin incision can either be posterior with a medial skin flap or direct medial, taking care to protect branches of the medial antebrachial cutaneous nerve which travels more anteriorly.



### Ulnar nerve

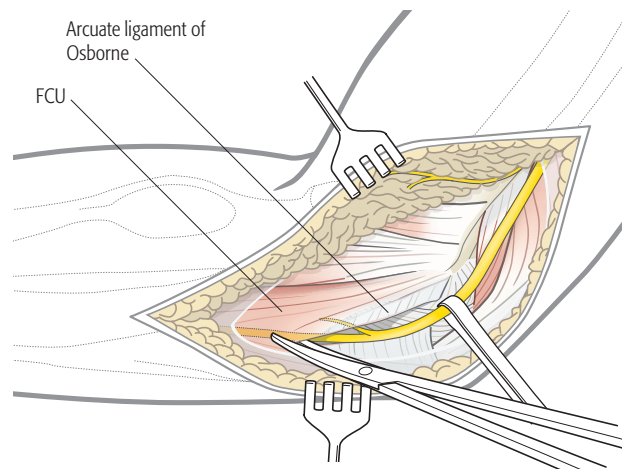
The ulnar nerve should be identified and protected. Generally, it is unroofed for 6 centimeters proximal and distal. Consider anterior subcutaneous transposition if you think this will keep the nerve safer.

**Pearl:** Always start with the exposure of the ulnar nerve proximally. It is easier and safer to identify the ulnar nerve proximally.



Follow the ulnar nerve distally as it goes under the fascia between the two heads of the flexor carpi ulnaris (FCU). Incise it with a pair of scissors and protective the first motor branch running to the humeral part of the FCU.

**Pearl:** Small, bleeding vessels can be best coagulated by using a bipolar coagulation pincette to protect the ulnar nerve.

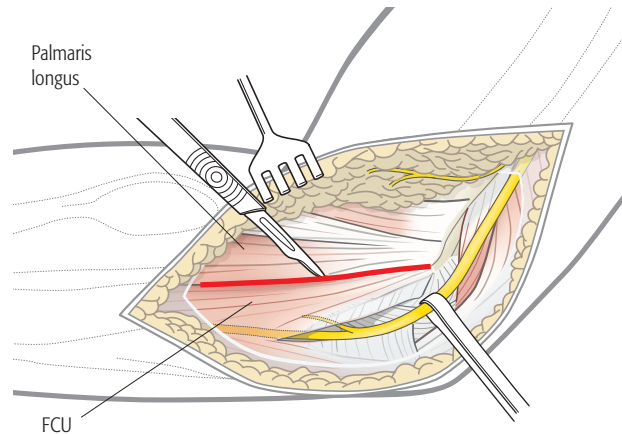




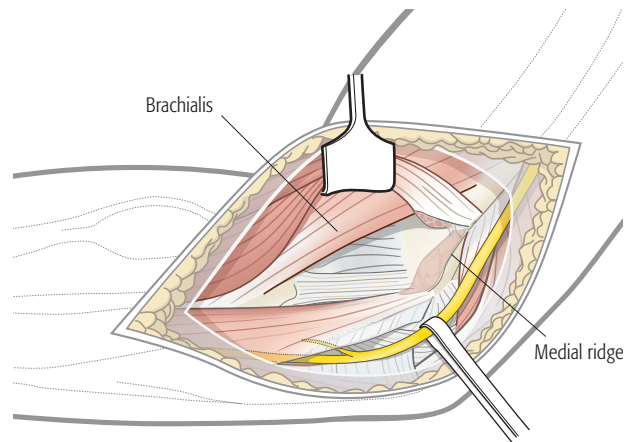
## Deep surgical dissection

### Splitting the flexor-pronator mass

Use blunt dissection to identify the anterior edge of the flexor-pronator mass, over the top of the brachialis and near to where the median nerve and brachial artery lie. With the ulnar nerve identified posteriorly, the flexor-pronator mass can be split, usually in the middle of the anterior-posterior width, but sometimes more posteriorly to get better access to the anteromedial coronoid. Elevate the palmaris longus, flexor carpi radialis and pronator teres origins off the medial epicondyle.



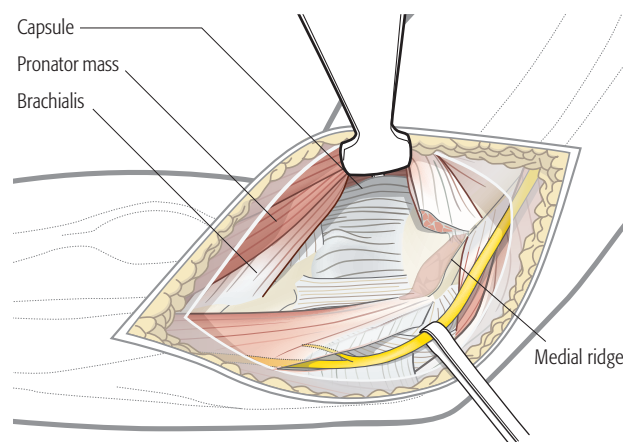
Extend this dissection proximally by extra-periosteal dissection of the brachialis muscle and the flexor-pronator mass off the medial supracondylar ridge of the distal humerus and the anterior elbow capsule.



### Exposure to the medial coronoid

Using blunt Hohmann retractors, the exposure can be improved across the entire anterior elbow joint.

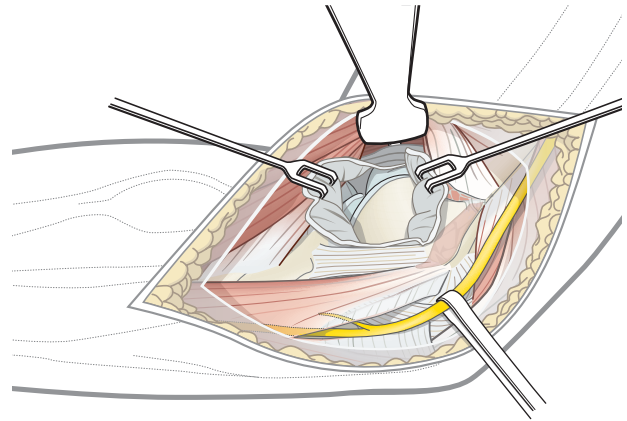
One can split the pronator mass more distally for better exposure to the medial coronoid, for instance if a longer plate fixation is planned.





## Capsulotomy

The elbow joint can be entered with an anterior capsulotomy or capsulectomy depending on the circumstances.

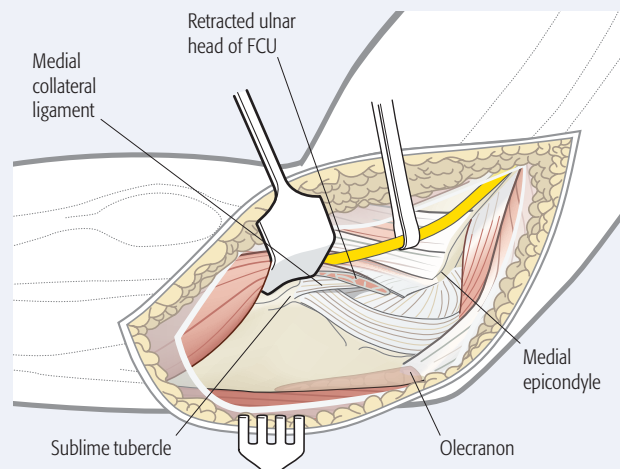




## 6.6 Medial Approach: Taylor and Scham

### Surgical approach

The Taylor and Scham approach is a good choice for medial plate fixation of large, basilar fractures of the coronoid.

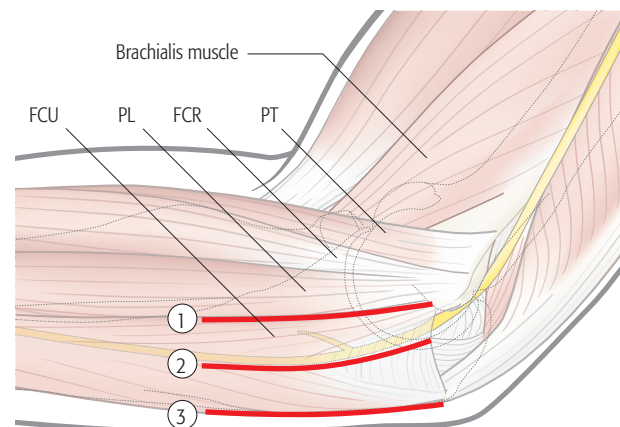


### Medial approaches

The interval that splits the flexor pronator mass and elevates the anterior part (pronator teres (PT), flexor carpi radialis (FCR), and palmaris longus (PL)) along with brachialis from the anterior elbow capsule gives good access to the anterior elbow capsule and the tip of the olecranon also known as the Hotchkiss “over the top” approach (**1**). The access to the medial facet of the coronoid is limited and there is also poor access to the base of the coronoid. For access to the medial facet, use the interval where the ulnar nerve lies between the heads of the flexor carpi ulnaris (FCU split; **2**).

For access to the base consider elevating the entire flexor-pronator mass from posterior to anterior (Taylor and Scham; **3**).

In the following the Taylor and Scham approach is described.

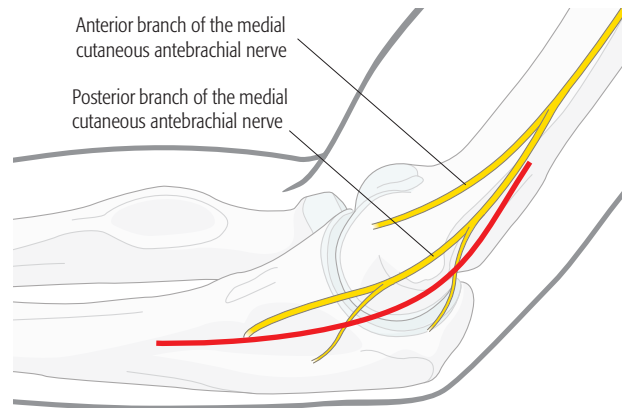






### Skin incision

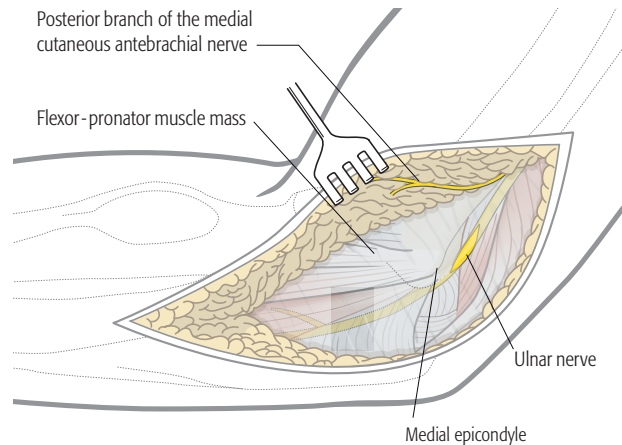
The skin incision can either be posterior with a medial skin flap or direct medial, taking care to protect the posterior branches of the medial antebrachial cutaneous nerve



### Ulnar nerve

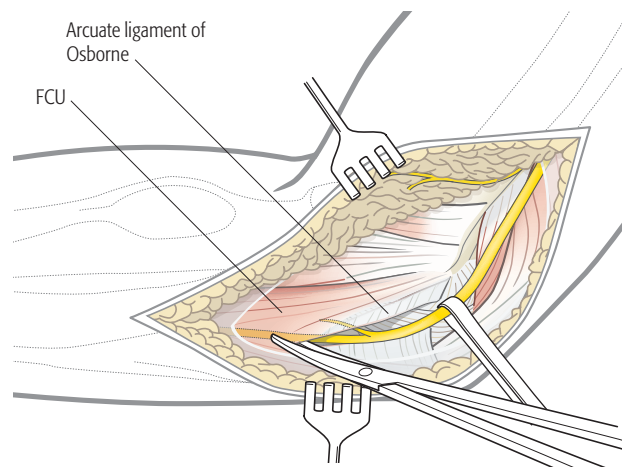
The ulnar nerve should be identified and protected. Generally, it is unroofed for 6 centimeters proximal and distal to the epicondyle. Consider anterior subcutaneous transposition if you think this will keep the nerve safer.

**Pearl:** Always start with the exposure of the ulnar nerve proximally as it is easier and safer.



Follow the ulnar nerve distally as it goes under the fascia between the two heads of the flexor carpi ulnaris (FCU). Incise it with a pair of scissors and protect the first motor branch running to the humeral part of the FCU.

**Pearl:** Small, bleeding vessels can be best coagulated by using a bipolar coagulation pincette to protect the ulnar nerve.



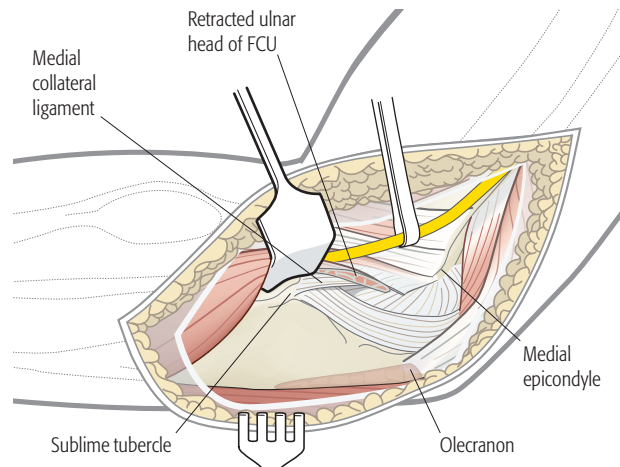




### Muscle elevation

Elevate the FCU and the entire flexor-pronator mass extra-periosteally from posterior to anterior starting at the crest of the ulnar shaft and the flat surface of the olecranon using a blunt elevator. You should expose the base of the coronoid fracture. If the ulnar nerve is at risk, transpose it anteriorly into the subcutaneous tissues.

**Pearl:** It is crucial to preserve the medial collateral ligament. Sometimes it gets difficult to distinguish the tendinous origin of FCU from the fibers of the medial collateral ligament. It is helpful to dissect from distal to proximal towards the sublime tubercle which is usually palpable. As long as the dissection is extra-periosteal and only muscle is elevated from the bone, the ligament should be safe.



If access to the anterior capsule is needed, make a second more anterior interval such as the “over the top” exposure. Elevation of the origin of the flexor-pronator mass off the medial supracondylar ridge of the distal humerus, gives good exposure, but is destructive and should be avoided if possible.

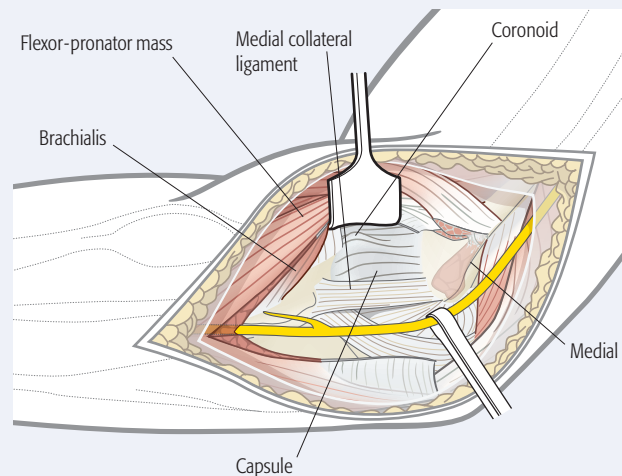




## 6.7 Medial Approach: FCU split

### 1 Surgical approach

**Fig 1.7-1** The Taylor and Scham approach is a good choice for medial plate fixation of large, basilar fractures of the coronoid.

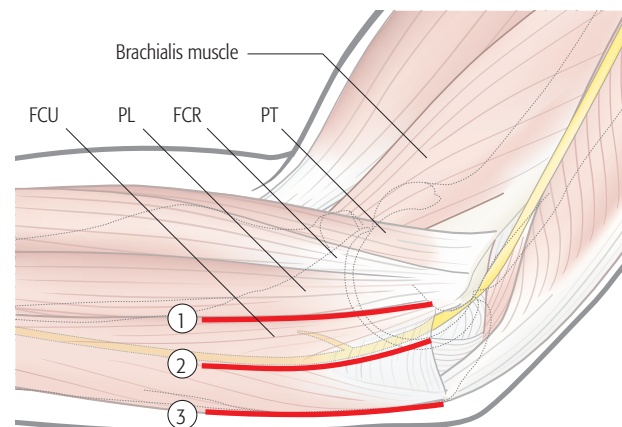


### 2 Medial approaches

**Fig 1.7-2** The interval that splits the flexor pronator mass and elevates the anterior part (pronator teres (PT), flexor carpi radialis (FCR), and palmaris longus (PL)) along with brachialis from the anterior elbow capsule gives good access to the anterior elbow capsule and the tip of the olecranon also known as the Hotchkiss “over the top” approach (**1**). The access to the medial facet of the coronoid is limited and there is also poor access to the base of the coronoid. For access to the medial facet, use the interval where the ulnar nerve lies between the heads of the flexor carpi ulnaris (FCU split; **2**).

For access to the base consider elevating the entire flexor-pronator mass from posterior to anterior (Taylor and Scham; **3**).

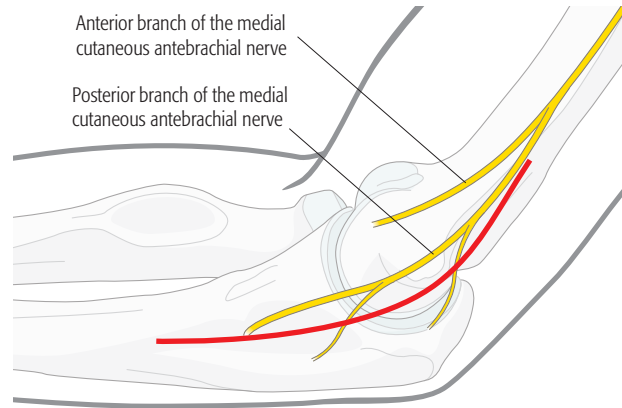
In the following the Taylor and Scham approach is described.





### 3 Skin incision

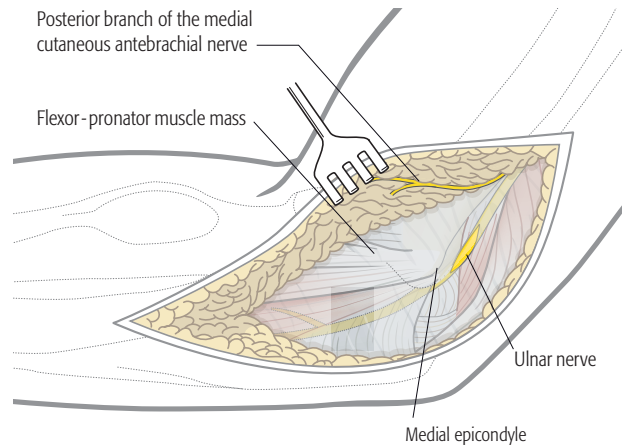
**Fig 1.7-3** The skin incision can either be posterior with a medial skin flap or direct medial, taking care to protect the posterior branches of the medial antebrachial cutaneous nerve.



### 4 Ulnar nerve

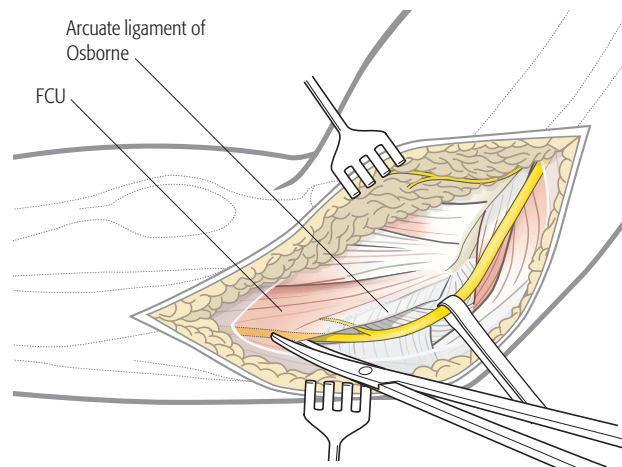
**Fig 1.7-4a** The ulnar nerve should be identified and protected. Generally, it is unroofed for 6 centimeters proximal and distal to the epicondyle. Consider anterior subcutaneous transposition if you think this will keep the nerve safer.

**Pearl:** Always start with the exposure of the ulnar nerve proximally as it is easier and safer.



**Fig 1.7-4b** Follow the ulnar nerve distally as it goes under the fascia between the two heads of the flexor carpi ulnaris (FCU). Incise it with a pair of scissors and protect the first motor branch running to the humeral part of the FCU.

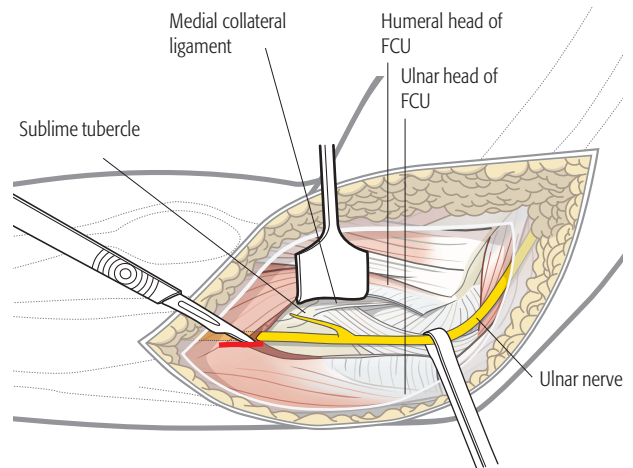
**Pearl:** Small, bleeding vessels can be best coagulated by using a bipolar coagulation pincette to protect the ulnar nerve.





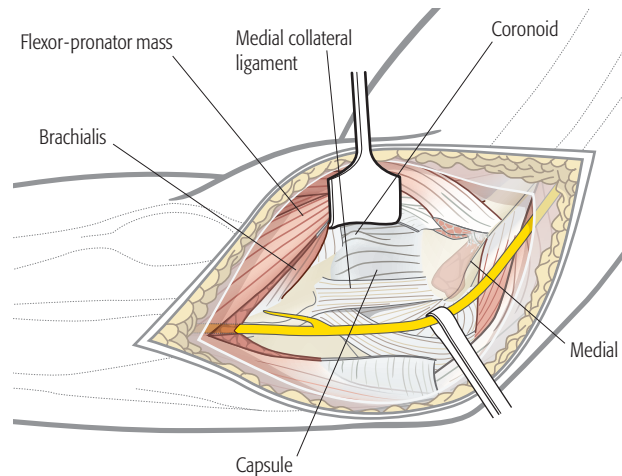
## 6 Splitting the FCU

**Fig 1.7-6a** Use the course of the ulnar nerve to distinguish the humeral and the ulnar part of the FCU. Start the dissection distally and elevate the humeral part of the FCU extra-periosteally off the coronoid, medial collateral ligament (MCL), and anterior elbow capsule. The MCL travels from the medial epicondyle to the sublime tubercle which is usually palpable.



**Fig 1.7-6b** For better exposure to the medial coronoid, the exposure can be extended distally and proximally. Distally one can split the FCU further down. Proximally one can extend the dissection by sharp, subperiosteal elevation of the flexor-pronator mass off the medial supracondylar ridge of the distal humerus, although this is not usually necessary.

Both, the brachial muscle and the flexor-pronator mass can be elevated off the anterior joint capsule.



## 7 Capsulotomy

**Fig 1.7-7** The elbow joint can further be opened with an anterior capsulotomy.

