

Pol Rommens | Peter Trafton | Martin Jaeger

4 Humeral shaft

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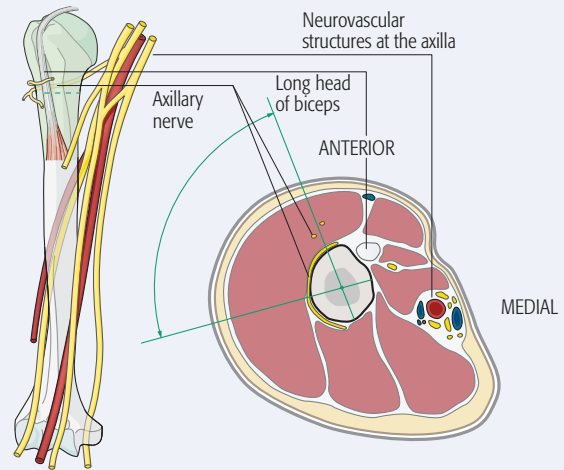
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4.1 Safe zones for percutaneous pins or screws

Surgical approach

Inserting percutaneous instrumentation through safe zones reduces the risk of damage to neurovascular structures.
Safe zones for percutaneous pins or screws



Introduction

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

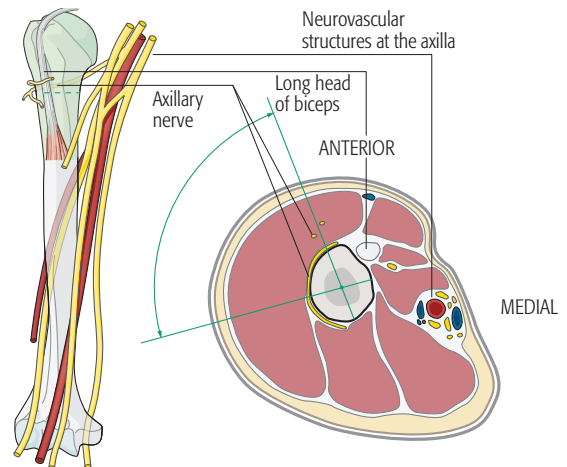


Safe zone in the proximal third

Pins or screws are inserted from a (antero-) lateral direction through the deltoid muscle.

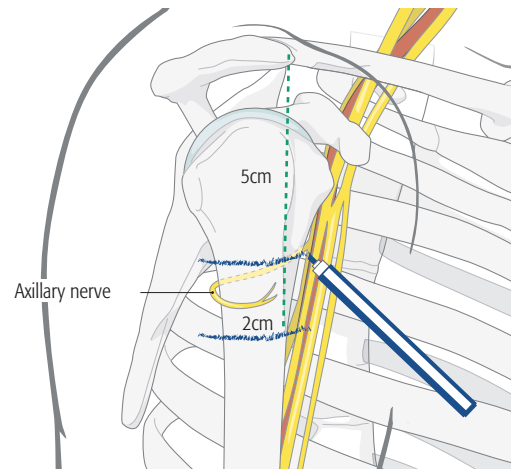
Avoid damage to the axillary nerve (as shown in the next illustration) and the long biceps tendon.

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

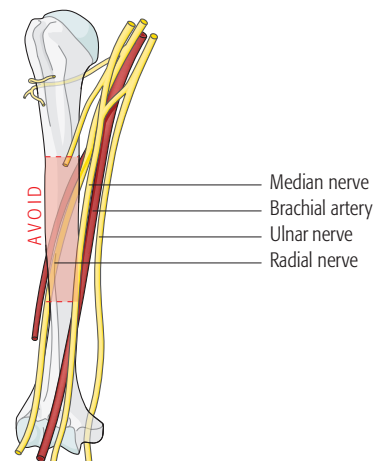


The axillary nerve runs dorsolaterally around the humeral metaphysis, about 5-7 cm below the acromion.

No safe zone in the middle third



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



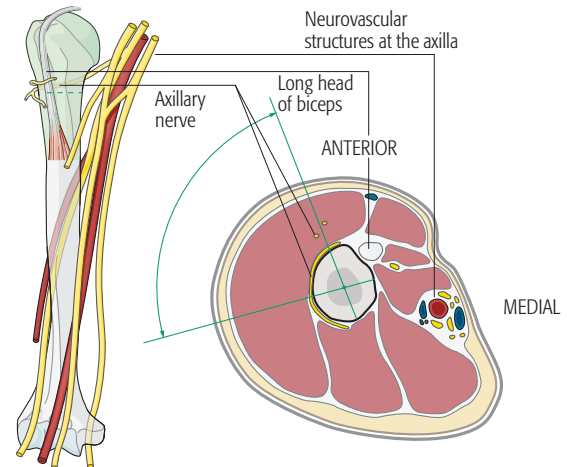


Safe zone in the distal third

Classically, pins are inserted from a posterior (alternatively from a posterolateral or posteromedial) direction through the triceps muscle, to stay within the safe zone and to avoid damage to the radial nerve.

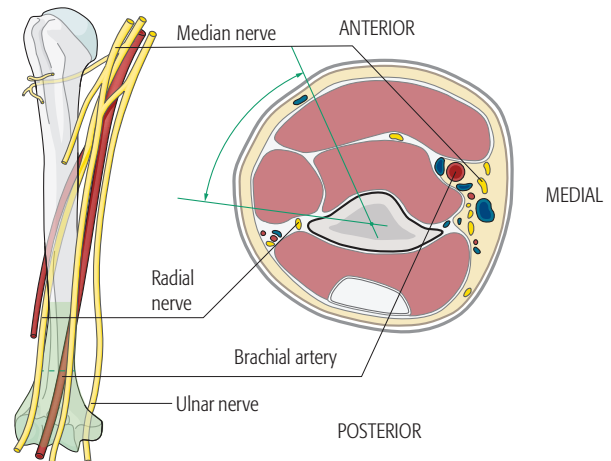
Avoid penetration of the olecranon fossa.

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



The safe zone in the distal third is usually not accessible in polytraumatized patients, who are supine. In addition, a posteriorly inserted pin may irritate the triceps tendon and may be uncomfortable to position the arm in bed.

Therefore, consider placing the pin laterally within the dangerous zone of the radial nerve. To reduce radial nerve injuries, use incisions which are large enough to ensure palpation and/or direct visualization of the radial nerve (no stab incisions).



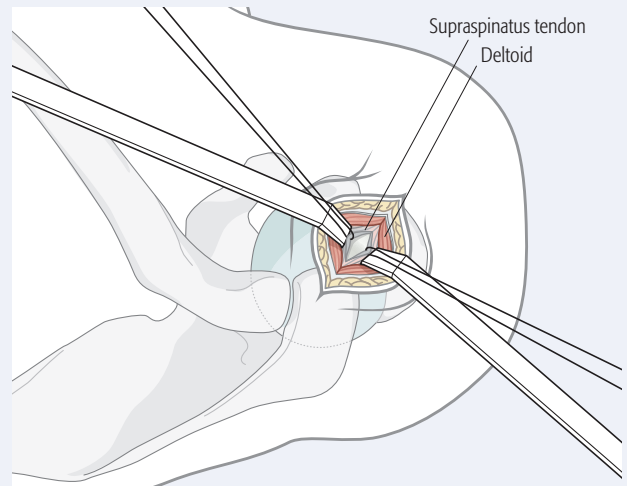


4.3 Antegrade nailing approach

Surgical approach

The humeral head is exposed via an anterolateral incision and the entry point is determined. Antegrade nailing involves entry through the rotator cuff. Care should be taken to minimize injury, and to repair the tendon.

Anterolateral transdeltoid approach for antegrade nailing



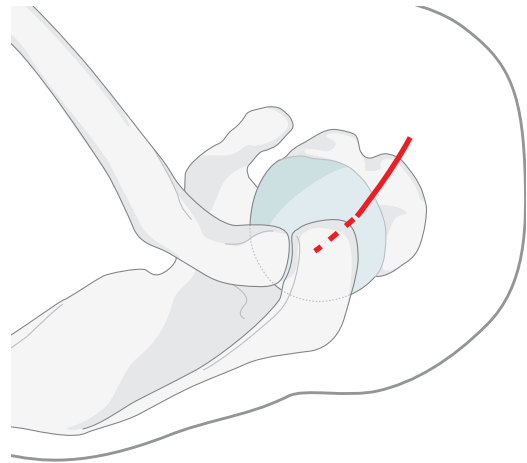
Introduction

The humeral head is exposed via an anterolateral incision and the entry point is determined. Antegrade nailing involves entry through the rotator cuff. Care should be taken to minimize injury, and to repair the tendon.



Skin incision

Make a small skin incision from the anterolateral edge of the acromion, distally towards the deltoid insertion. Incise the subcutaneous tissue sharply.



Exposure of the humerus

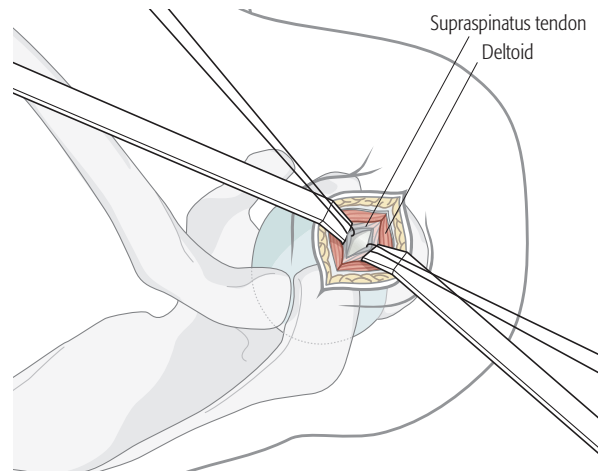
Split and retract the deltoid muscle within the raphe.

Incise and/or resect partially the subdeltoid bursa.

Incise the supraspinatus tendon in line with its fibers with a pointed scalpel blade. Retract both borders of the tendon with sutures.

Expose the superior humeral head cartilage medial to the greater tuberosity.

The ideal entry exposure is just posterior to the long head of the biceps tendon.

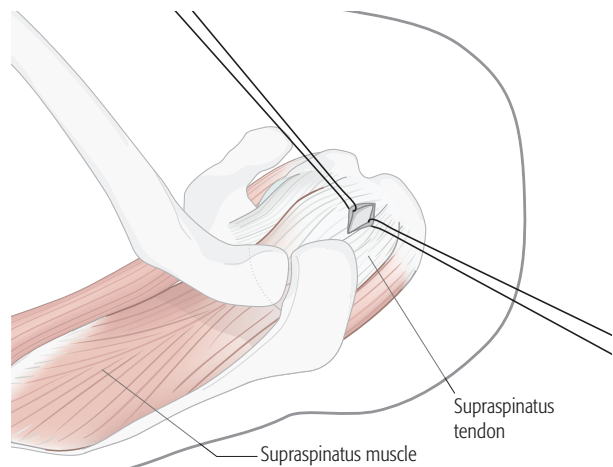


Pitfall: Damage to rotator cuff

Access to the entry site is through the supraspinatus tendon.

Damage to the rotator cuff is minimized by sharp incision. The edges of the incision may be retracted by sutures held with clamps or bent K-wires to avoid damage to the tendon.

If reamers are used, they should be passed carefully through the tendon before reaming. It is crucial to use sleeves for the reamers.





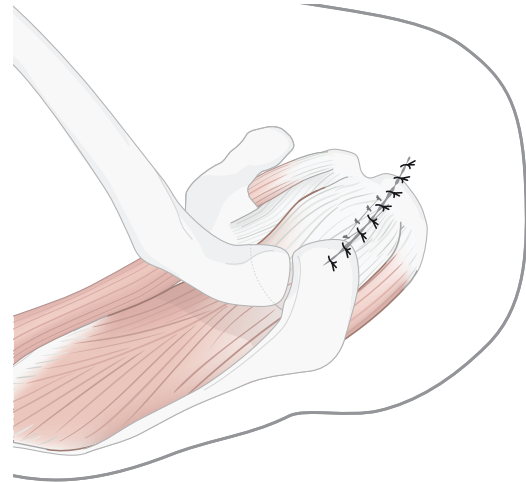
Wound closure

Irrigate and clean all wounds.

Close the supraspinatus tendon carefully.

A drain may be placed in the subacromial space.

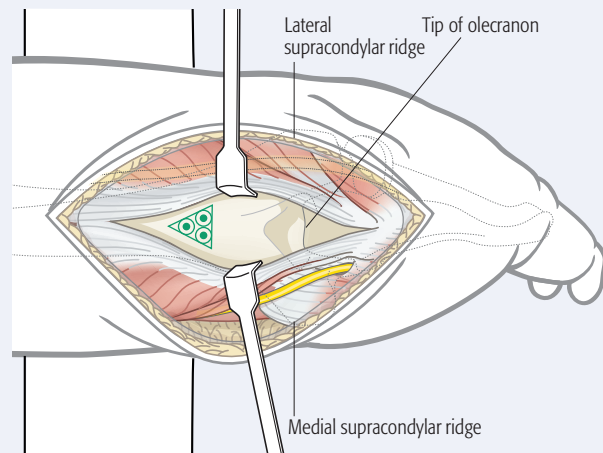
Close the deltoid muscle, subcutaneous tissue, and skin separately.



4.4 Retrograde nailing approach

Surgical approach

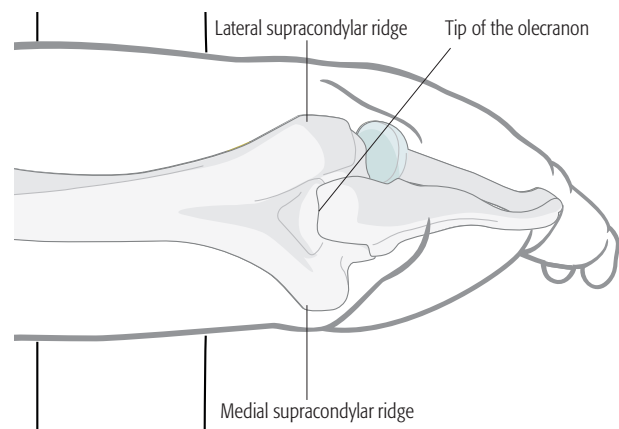
The retrograde nailing approach requires opening the medullary canal just proximal to the olecranon fossa. The soft tissues are opened longitudinally in the line of the humeral shaft.



Introduction

The retrograde nailing approach requires opening the medullary canal just proximal to the olecranon fossa. Landmarks are:

- Medial supracondylar ridge
- Lateral supracondylar ridge
- Tip of the olecranon
- Humeral shaft

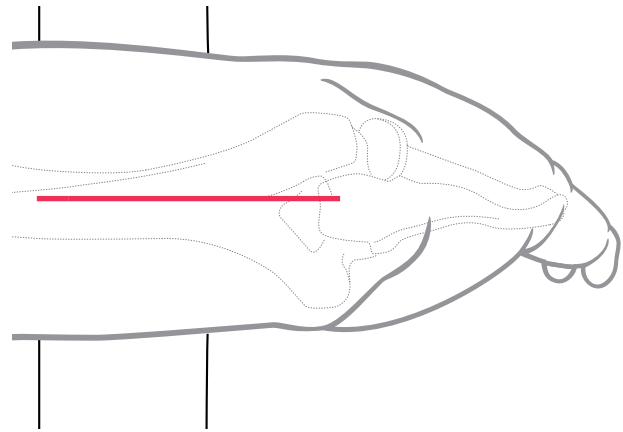




Incision and deep dissection

Make an 8-10 cm straight skin incision on the dorsal aspect of the upper arm, proximally from the tip of the olecranon and in line with the longitudinal axis of the humerus.

Sharply incise the subcutaneous layer.

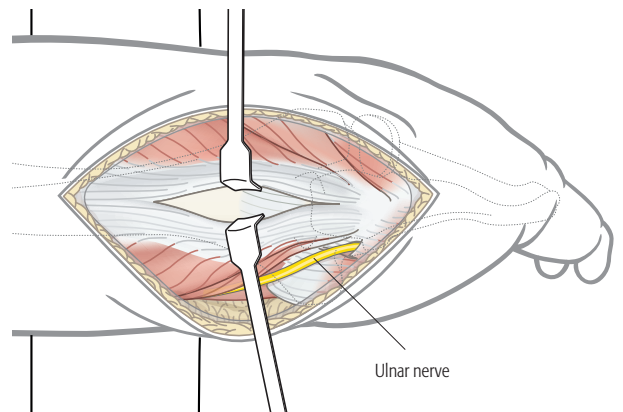


Identify the ulnar nerve.

Split the triceps tendon longitudinally. Separate the edges with right angle retractors.

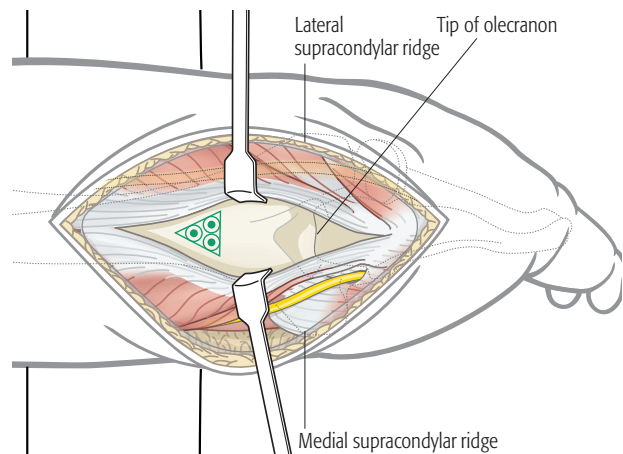
Expose the dorsal supracondylar region of the humerus.

Protect the elbow joint capsule during preparation of the dorsal bone surface.



The visible area of the bone should extend proximally for about 25 mm from the edge of the olecranon fossa for optimal access to explore the entry point (green triangle).

Palpate the medial and lateral columns of the distal humerus to confirm the bony anatomy, especially the center of the humerus.

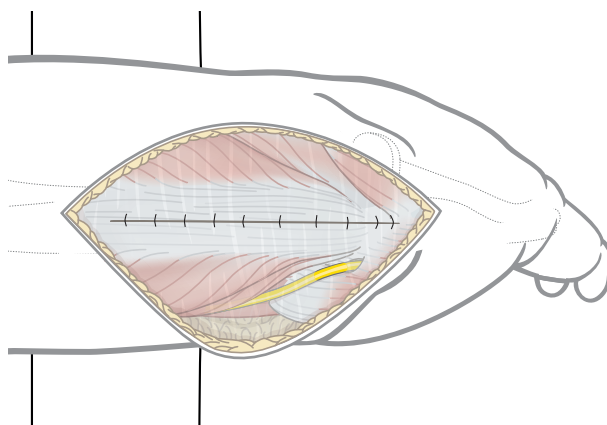




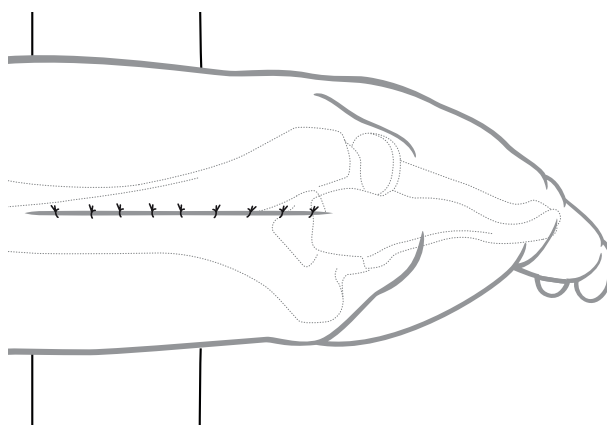
Wound closure

Irrigate and clean the wounds.

Close the incised triceps tendon and the posterior fascia of the upper arm with sutures in layers.



One drainage tube may be inserted into the main wound. Close the skin incision. For the stab incisions, perform skin closure only.

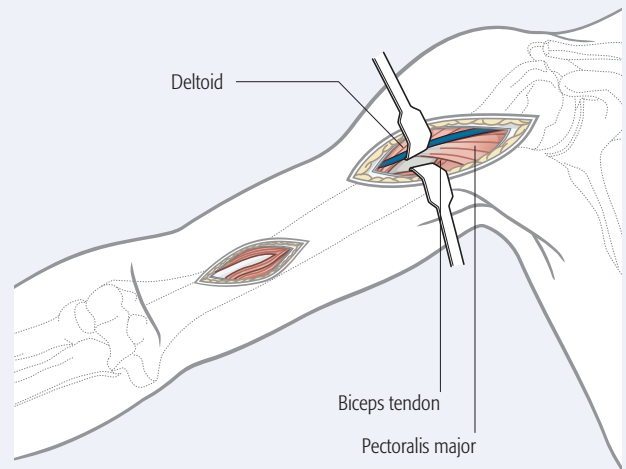




4.4 MIO approach (anterior)

Surgical approach

The minimally invasive osteosynthesis approach allows for subcutaneous plate insertion through a tunnel. Typically, the plate will be introduced through the distal portal.



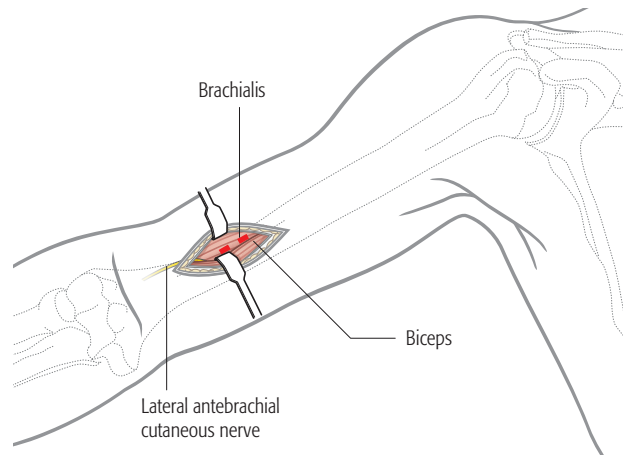
Introduction

The minimally invasive osteosynthesis approach allows for subcutaneous plate insertion through a tunnel. Typically, the plate will be introduced through the distal portal as shown below.

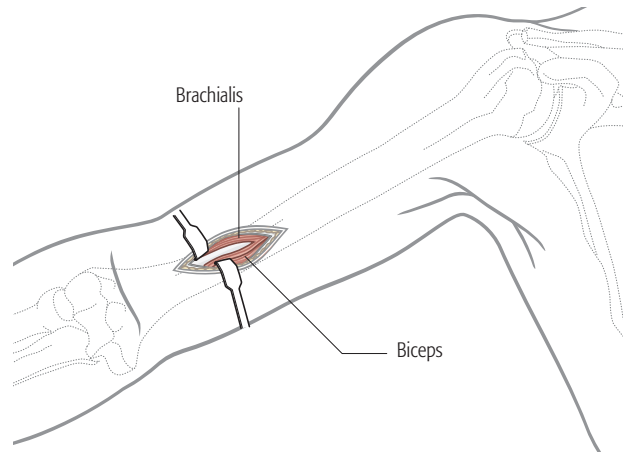


Distal portal

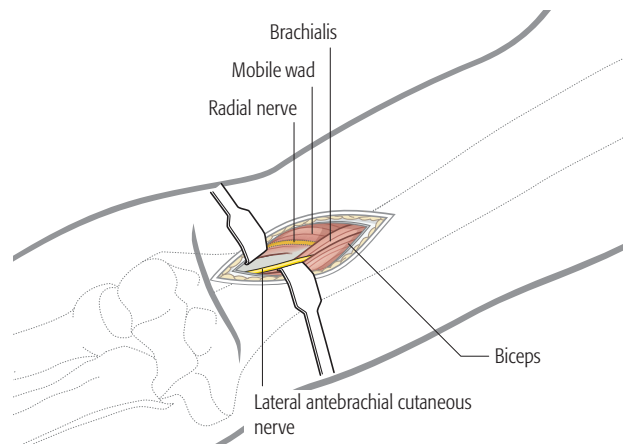
Distal access is gained through the brachialis muscle, splitting apart its medial and lateral portions for approximately 5 cm to reveal the anterior humeral surface. Distally the lateral antebrachial cutaneous nerve lies between biceps and brachialis. It should be identified and protected by medial retraction. The radial nerve lies laterally, protected by the lateral portion of brachialis.



Brachialis has been identified deep to the biceps. Its fibers have been split longitudinally, providing extraperiosteal access to the anterior distal humeral shaft.



For more distal fractures, purchase on the lateral humeral column can be gained through a slightly more distal incision beginning at the joint crease and extending 5-6 cm proximally. Develop the interval between biceps and brachialis medially and the “mobile wad” (brachioradialis, extensor carpi radialis longus and brevis) laterally. The radial nerve must be protected here. Retract or incise the brachialis, as needed, to gain extraperiosteal access to the antero-lateral aspect of the lateral column of the distal humerus.

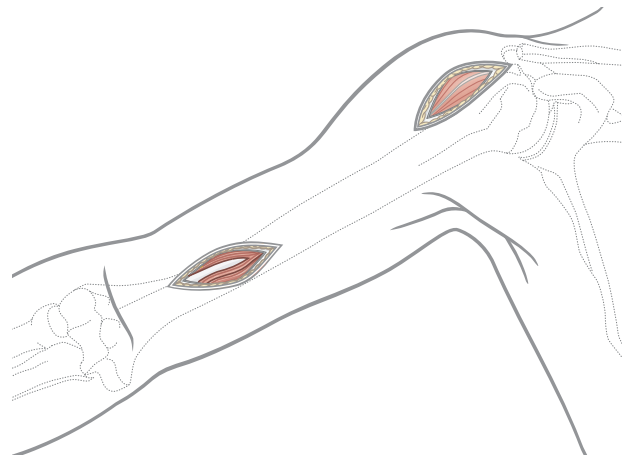




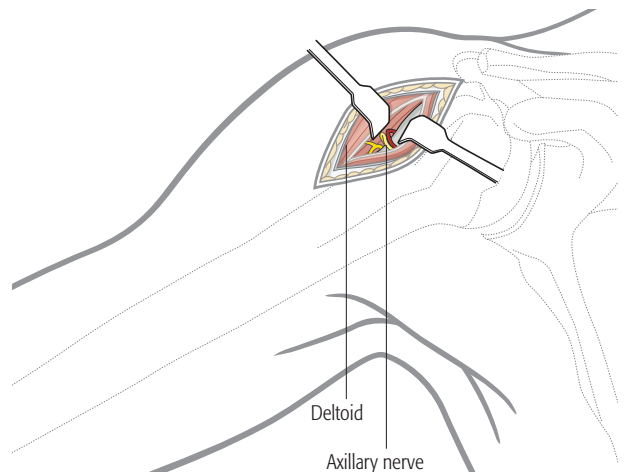
Proximal portal (anterior deltoid split)

The fracture morphology determines the length of the plate required, and the site for proximal fixation. This dictates the site of the proximal portal.

For a more proximal fixation, expose the anterior deltoid raphe through an incision made distally from the anterolateral acromial tip.

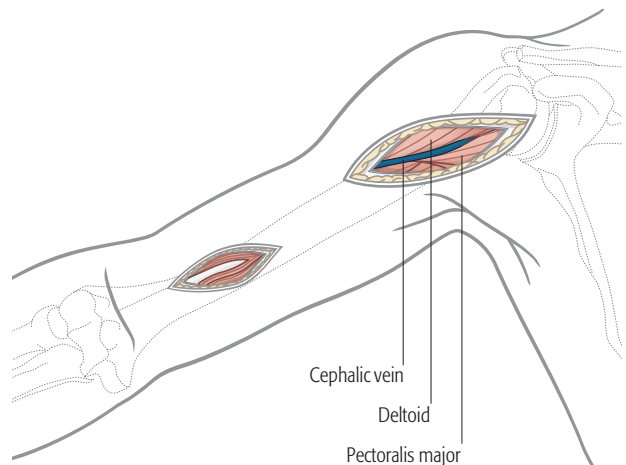


Carefully dissect through the raphe, finding and protecting the axillary nerve and its accompanying vessels. The proximal humerus lies beneath these. Mobilize this neurovascular bundle for extraperiosteal access to the proximal humerus.



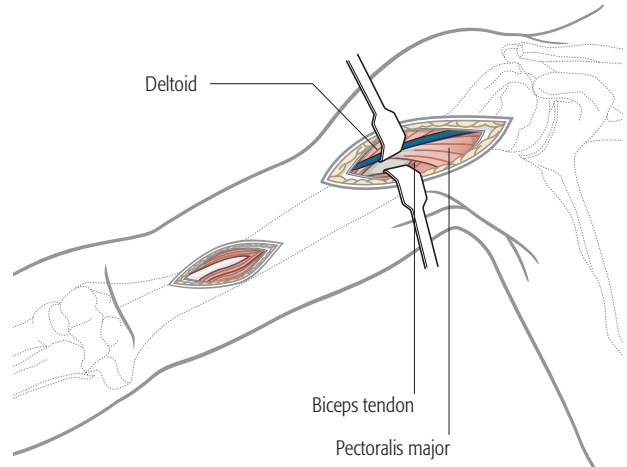
Proximal portal (deltobicipital)

For shorter plate application in more distal fractures the humerus may be approached through the interval between the deltoid and biceps. The cephalic vein lies in this interval. Identify the vein and protect it while dissecting through the interval.



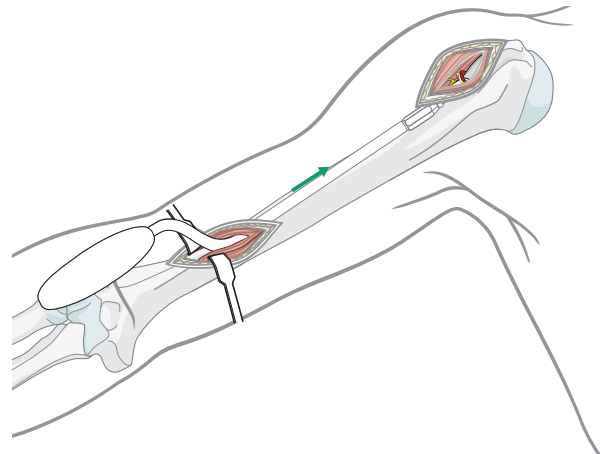


Dissect bluntly to the periosteal surface. Develop an area on the periosteal surface approximately 5 cm long. It is possible to release the anterior part of the deltoid insertion, if necessary, as this area of deltoid insertion is both long and broad.



Creating the tunnel

Create the extraperiosteal tunnel under brachialis with an instrument passed from the distal to the proximal incision.



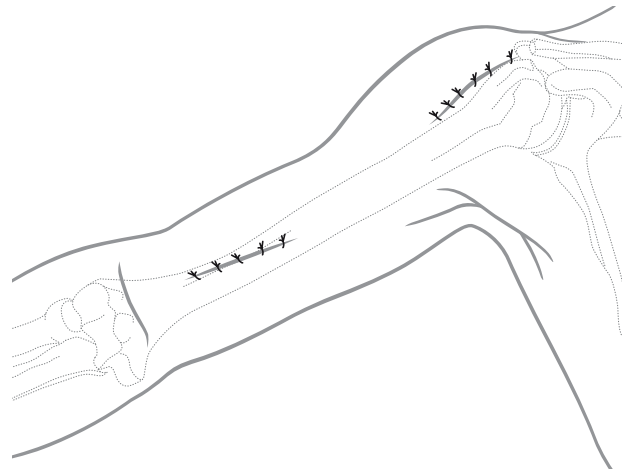
Pitfall: nerve damage

Take care not to injure the axillary nerve and its accompanying vessels especially when working from the proximal portal.



Wound closure

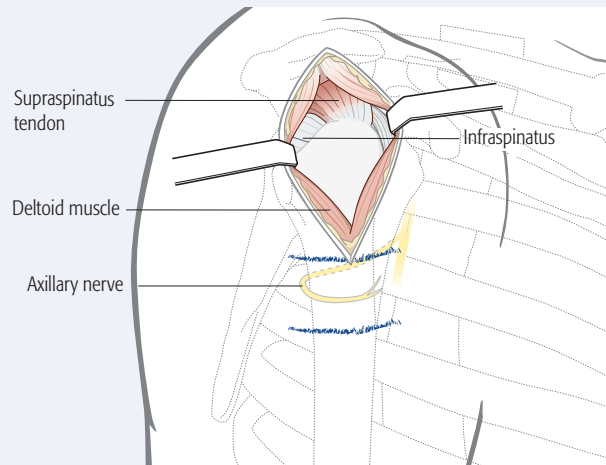
Close the incisions in layers in a standard manner.



4.5 MIO transdeltoid approach

Surgical approach

The MIO transdeltoid lateral approach can be used for the more proximal humeral shaft fractures. It is especially useful if there is an extension of the fracture into the greater tuberosity.

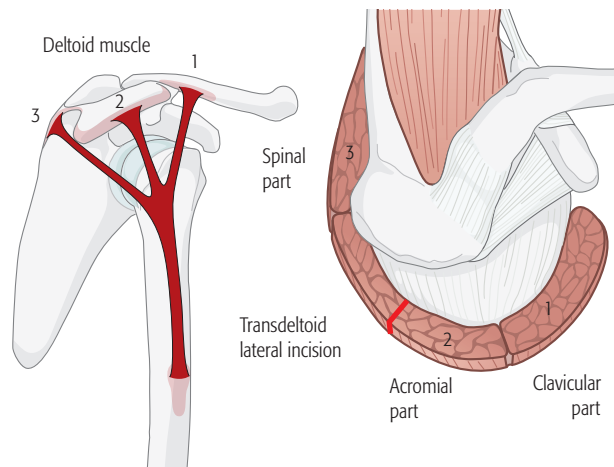


Introduction

The MIO transdeltoid lateral approach can be used for the more proximal humeral shaft fractures. It is especially useful if there is an extension of the fracture into the greater tuberosity.

This incision is placed between the acromial part (2) and the spinal part (3) of the deltoid muscle, as illustrated.

The skin incision should not extend more than 5 cm distally to the acromion, to protect the axillary nerve.



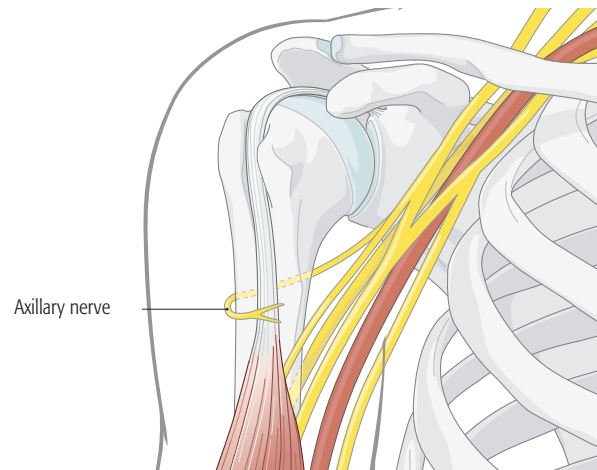


Anatomy

Neurovascular structures

The course of the axillary nerve must be kept in mind.

Note: The anterior motor branch of the axillary nerve crosses the humerus horizontally about 6 cm distal to the lateral border of the acromion. This distance does not vary significantly and is reliable.

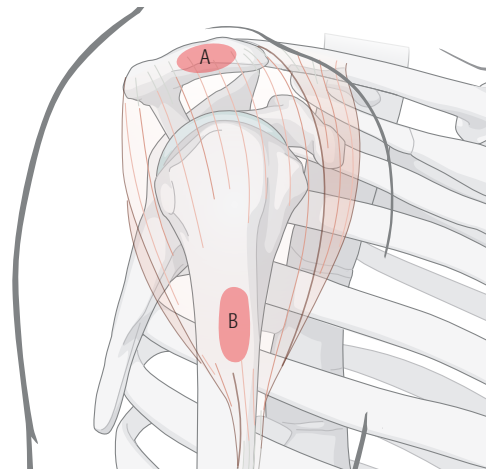


Anatomical landmarks

Anatomical landmarks for the transdeltoid lateral approach are:

- A)** Lateral border of the acromion
- B)** Lateral side of the humeral shaft

Both landmarks can easily be palpated.

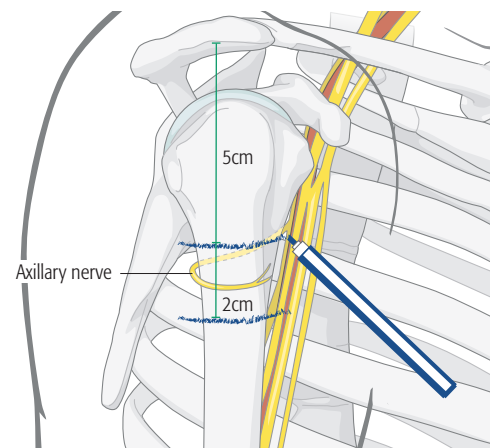


Skin incision

Axillary nerve

Before incising the skin, mark the distal limit of the approach, 5cm below the acromion, which is 1 cm above the course of the axillary nerve.

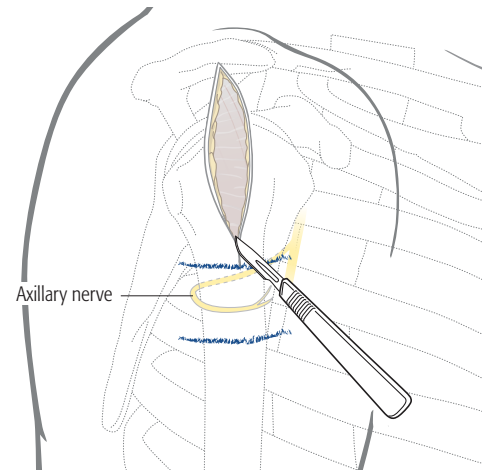
Mark a second line 2 cm distal to the first, below which the axillary nerve should not be encountered. The space between these two lines is the danger zone on the lateral humerus.





Skin incision

Make a skin incision from the lateral border of the acromion on 5 cm distally, parallel to the axis of the humerus.



Exposure of the middle third part of the deltoid muscle

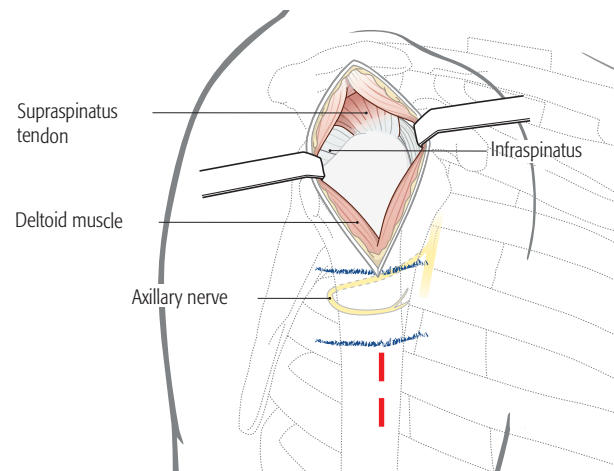
Expose the middle third (acromial) part of the deltoid muscle and split it between its fibers.

For maximum exposure, split the deltoid up to the margin of the acromion, but do not split it distally more than 5 cm from its origin to avoid damaging the axillary nerve and paralyzing the anterior part of the deltoid.

Palpate the axillary nerve on the deep surface of the deltoid muscle, distal to the incision. This nerve encircles the proximal humerus a little less than half way from the lateral margin of the acromion to the insertion of the deltoid muscle.

Hemorrhagic subdeltoid bursal tissue may need to be excised to expose the humeral head.

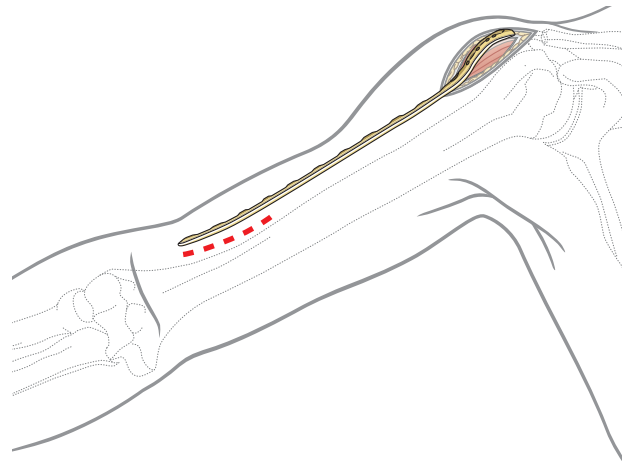
Pearl: To protect the axillary nerve from uncontrolled distal dissection, a stay suture may be placed at the inferior border of the deltoid split.



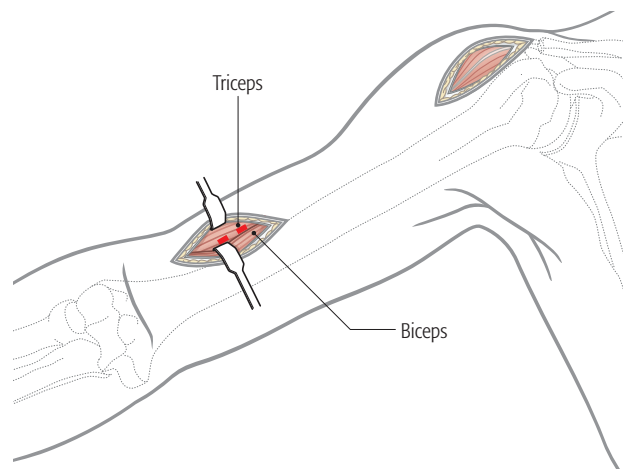


Distal incision

Place the selected plate on the arm with the proximal end level with the intended final placement. This indicates the site of the distal portal.



Distal access is gained between the biceps and triceps to reveal the lateral humeral surface. Depending on the level of the incision the radial nerve may have already entered the anterior compartment and is at risk. It should be identified and protected.

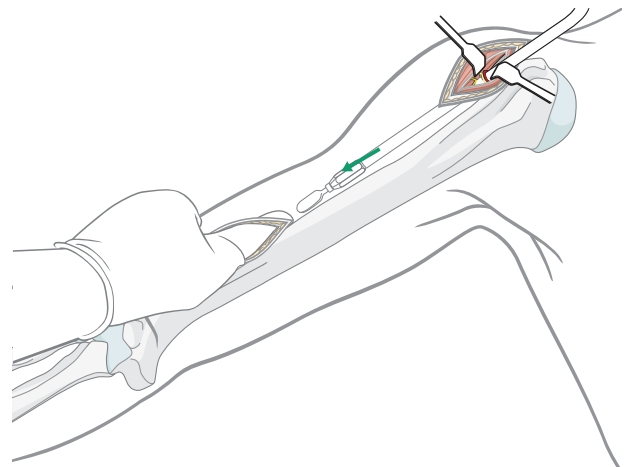


Creating the tunnel

Pass an instrument carefully under the axillary nerve and its vessels, to elevate them gently and create a plane deep to them.

The illustrated large probe or dissector is then used to pass distally beneath the deltoid and slid through the deltoid insertion.

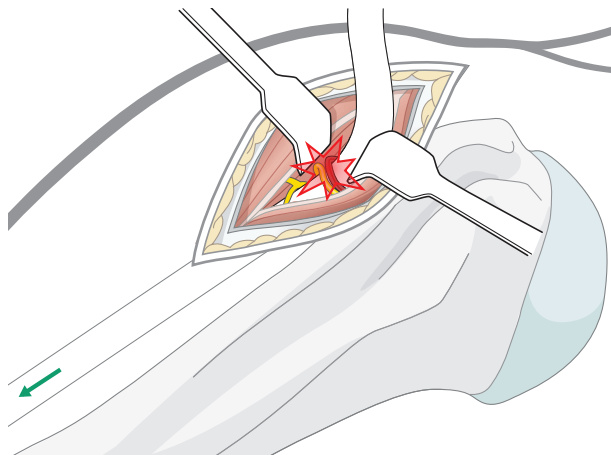
As the tip of the instrument nears the distal portal, it should be palpated and guided into alignment with the humeral shaft.





Pitfall: nerve damage

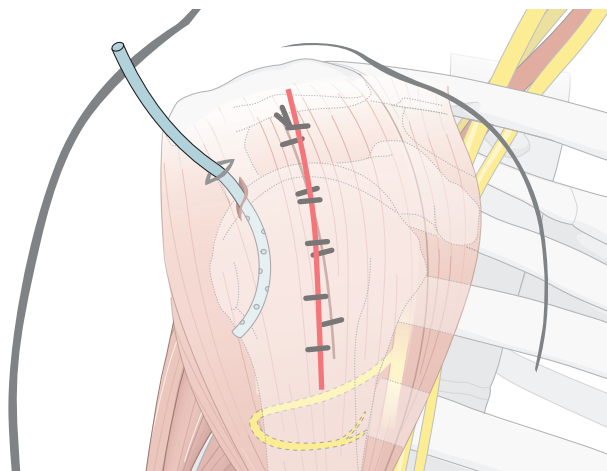
Take care not to injure the axillary nerve and its accompanying vessels.



Wound closure

After surgery irrigate the wound. Some surgeons place a drain beneath the deltoid muscle.

Close the deltoid fascia, the subcutaneous tissues and the skin.

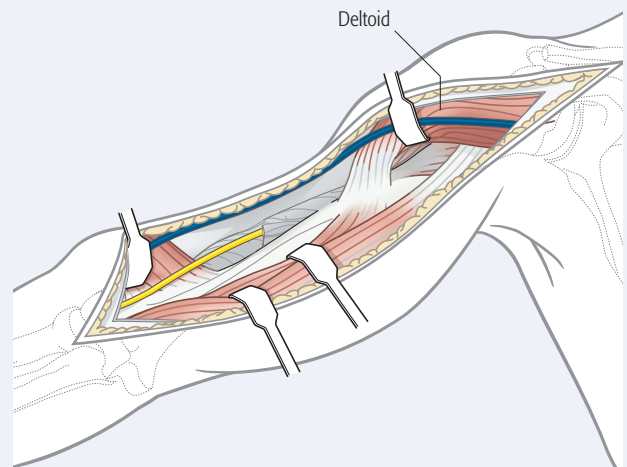




4.6 Anterolateral approach

Surgical approach

Plating of proximal humeral shaft fractures may be performed through the anterolateral approach. This approach can be extended distally for midshaft fractures.
Anterolateral approach to the humerus (after Henry)



Introduction

Plating of proximal humeral shaft fractures may be performed through the anterolateral approach. This approach can be extended distally for midshaft fractures.

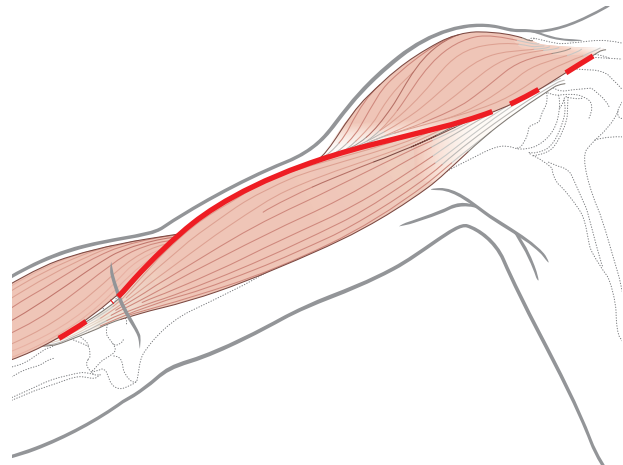


Skin incision

The complete incision is illustrated here. Depending on the fracture and its location, a smaller section might be used.

The incision follows a line extending from the interval distally between biceps and the mobile wad (brachioradialis and the wrist extensors) to the deltopectoral interval proximally, following the lateral edge of biceps and the anterior edge of the deltoid. The incision may also be performed from proximally to distally.

Minimize any detachment of subcutaneous tissue from the muscular fascia.

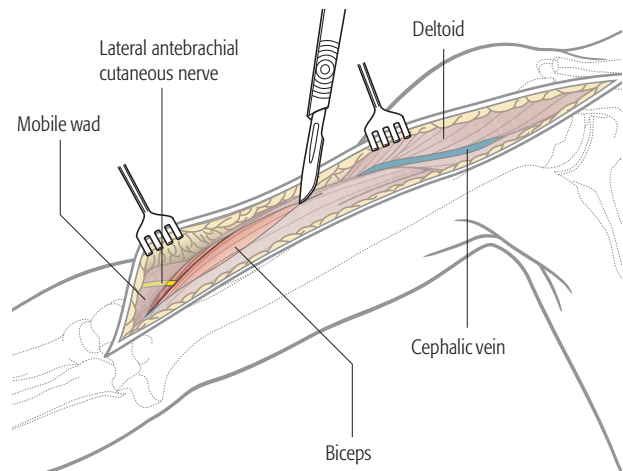


Superficial dissection

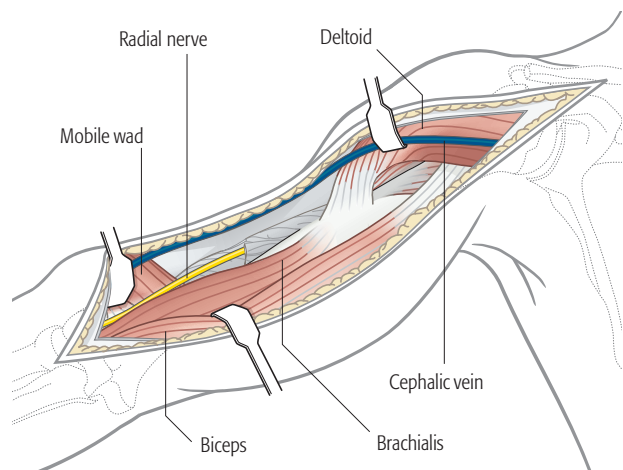
Incise the fascia carefully between biceps/brachialis and the mobile wad and extend proximally.

Look for the lateral cutaneous nerve of the forearm crossing distally. The radial nerve is deeper. Identify the nerve in the interval between biceps and the mobile wad and followed proximally as the incision is developed.

Proximally, look for the cephalic vein in the deltopectoral interval. If it is retracted with the deltoid, muscular tributaries are less likely to be torn.



Retract the biceps medially, and the mobile wad laterally to identify the radial nerve. The brachialis is now exposed.



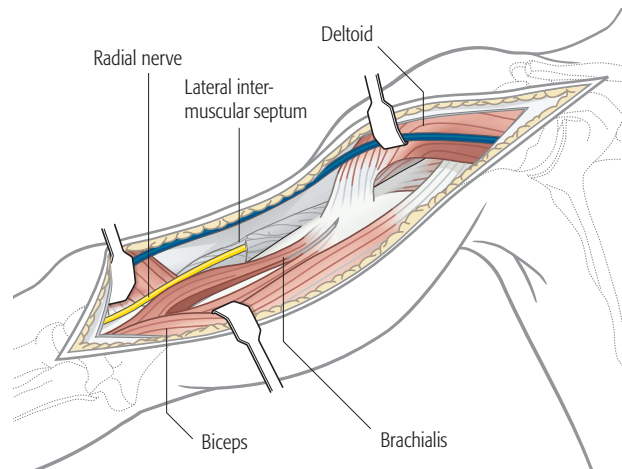


Deep dissection

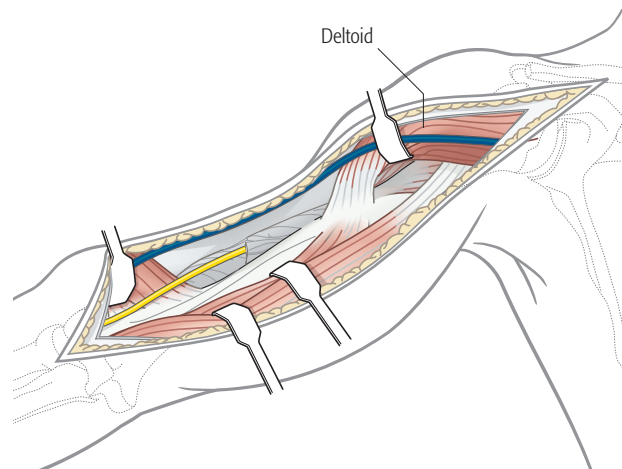
Dissect the brachialis within the neurovascular plane between the radial and the musculocutaneous nerves to maintain innervation of the brachialis.

If necessary release some of the muscle attachment proximally to allow the plate to lie on the bone.

Extend the dissection proximally, as needed, to the anterior border of the deltoid and along the deltopectoral interval.



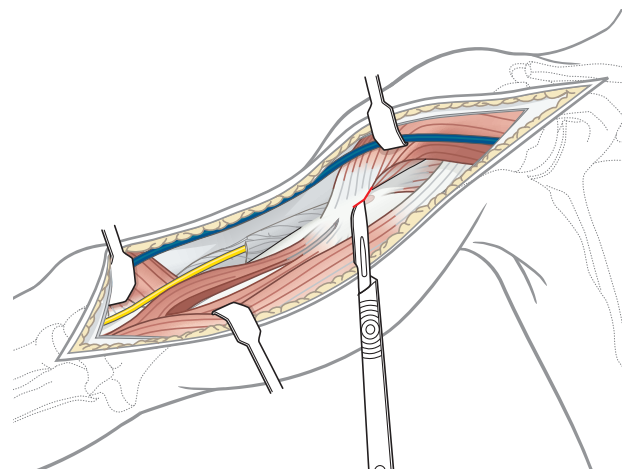
Alternatively, the brachialis may be retracted medially. Beware that this injures the radial nerve branch to the brachialis.



Partially release the deltoid insertion anteriorly, if necessary, and retract laterally to access the proximal humerus.

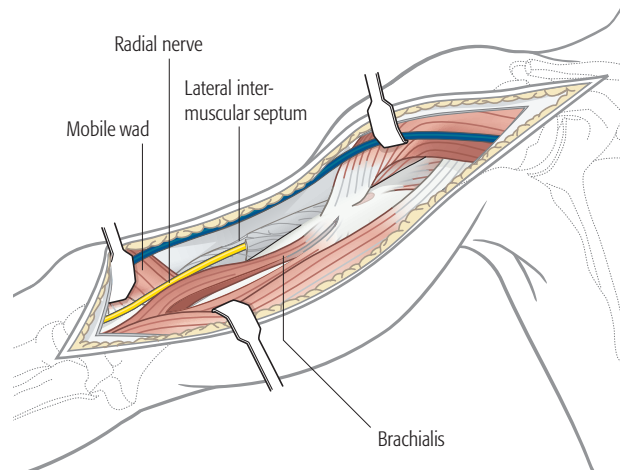
Alternatively dissect bluntly under the central deltoid insertion to allow for plate placement.

Leave as much muscle attached to bone as possible to preserve vascularity and reattach the released portion at the end of the procedure.



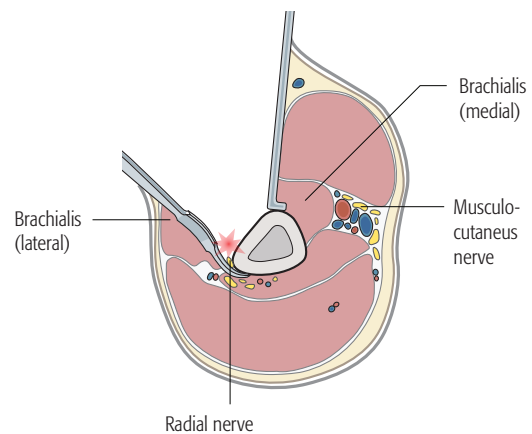


Distally, the anterior humerus has been exposed to the elbow joint, between the mobile wad and brachialis. Mobilize the radial nerve, as needed, to access the bone. Follow the nerve to the point where it passes through the lateral intermuscular septum.



Pitfall: injury to the radial nerve

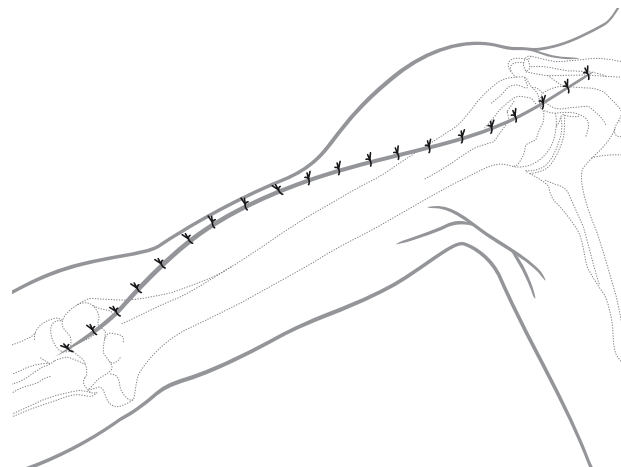
The radial nerve enters the anterior compartment by perforating the lateral intermuscular septum. The use of Hohmann retractors in the distal 2/5 of the humerus carries a high risk of iatrogenic nerve injury and should therefore be avoided.



Wound closure

Irrigate the wound. Placement of a drain underneath the deltoid muscle might be considered.

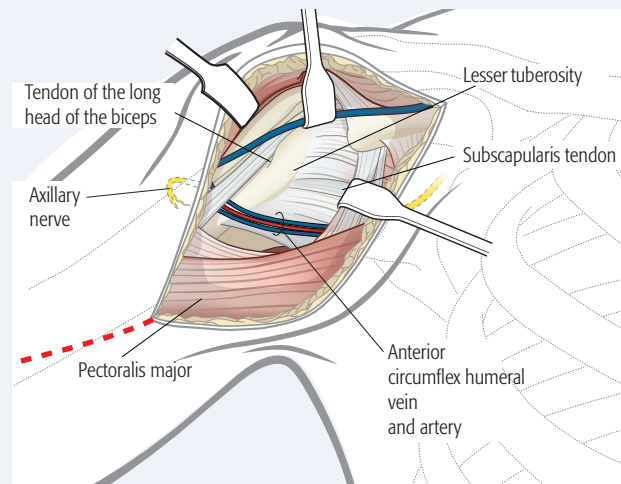
Close the subcutaneous tissues and the skin in layers in a standard manner.



4.7 Extended deltopectoral approach

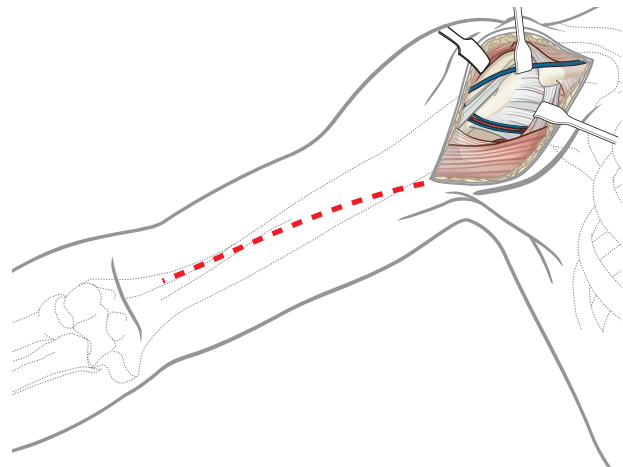
Surgical approach

The (anterior) extended deltopectoral approach can be used to access almost any humeral shaft fracture involving the proximal 4/5.



Introduction

The (anterior) extended deltopectoral approach can be used to access almost any humeral shaft fracture involving the proximal 4/5.



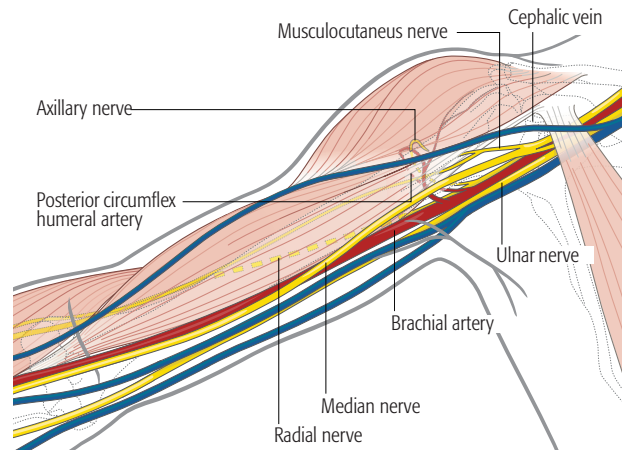


Anatomy of the upper arm

The course of the following neurovascular structures should be kept in mind:

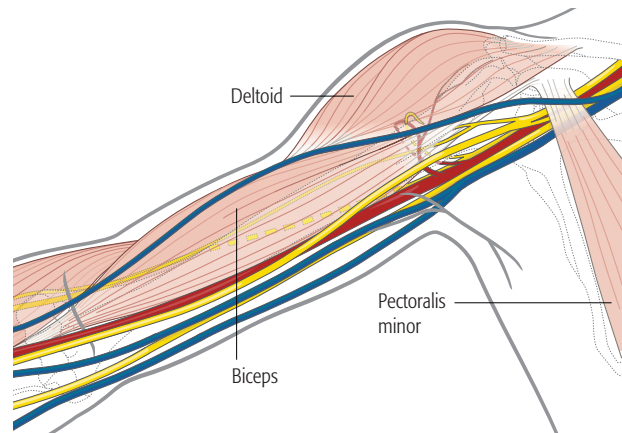
- Cephalic vein
- Posterior circumflex humeral artery
- Axillary nerve
- Musculocutaneous nerve
- Radial nerve
- Median nerve
- Ulnar nerve
- Brachial artery

Further neurovascular structures, eg the brachial plexus, are only at risk if there is a vigorous retraction.



Anatomy of the arm showing the neurovascular structures in relation to the following muscles:

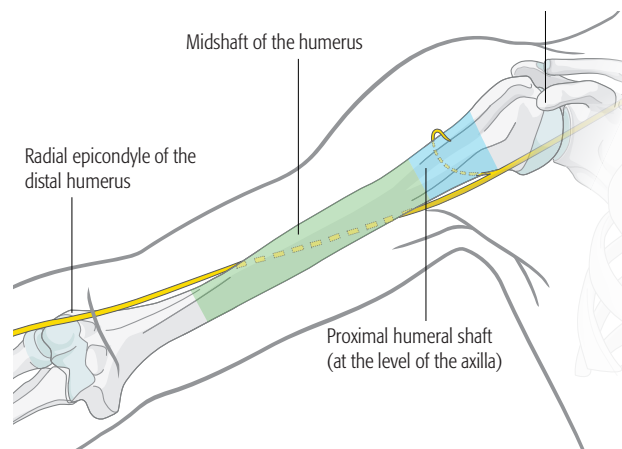
- Deltoid
- Biceps
- Pectoralis minor



Skin incision

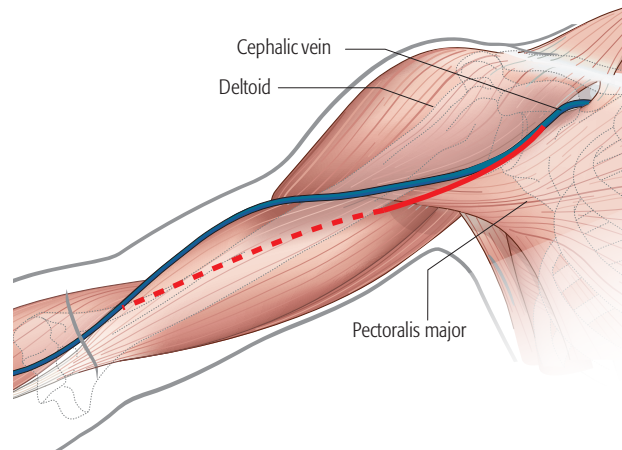
Palpable anatomical landmarks for the anterior deltopectoral approach are:

- Coracoid process
- Proximal humeral shaft (at the level of the axilla)
- Midshaft of the humerus
- Radial epicondyle of the distal humerus





The skin incision starts at the coracoid process and follows the humeral shaft distally towards the lateral epicondyle. The length of the skin incision depends on the planned plate length.



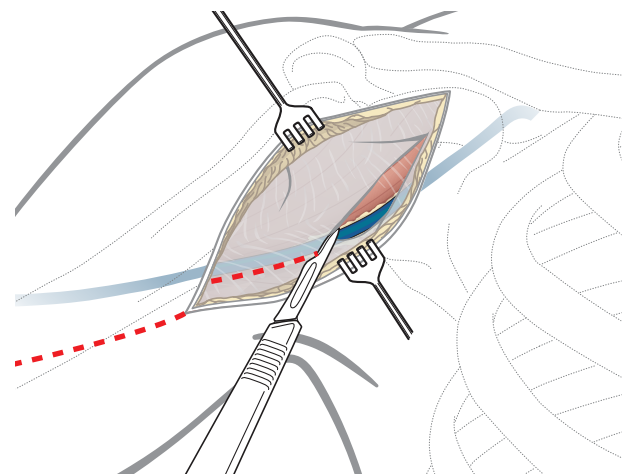
Exposure of the superficial fascia

Expose the deltopectoral groove with the cephalic vein. These structures can be identified by:

- The course of the muscle fibers
- The cephalic vein itself
- Fat tissue surrounding the vein

For better exposure it is recommended to dissect at the lateral border of the pectoralis major.

If in doubt, look for the deltopectoral groove at the proximal and/or distal end of the skin incision. (The sulcus is slightly more pronounced and in cases of revision surgery less scarred.)

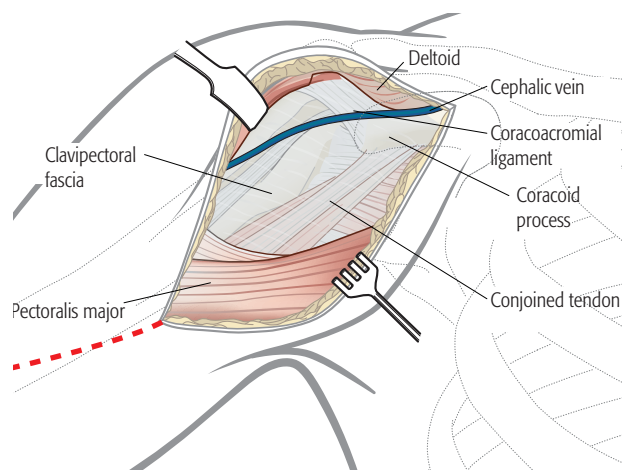


Dissection down to the deltopectoral groove

Retract the cephalic vein laterally and open along the groove. If retracted laterally, the anatomical drainage of blood from the deltoid muscle is respected but it is at risk of damage by retractors during surgery. In any case, preserve the cephalic vein to reduce the surgical edema of the limb.

Failure to find the deltopectoral groove can lead to difficulty in dissection of the deltoid and possibly to denervation of the anterior portion of the deltoid.

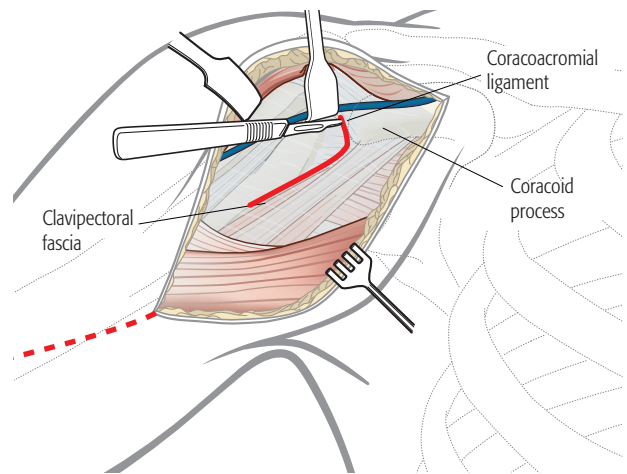
Bluntly dissect between and under the deltoid and pectoralis muscles down to expose the clavipectoral fascia.



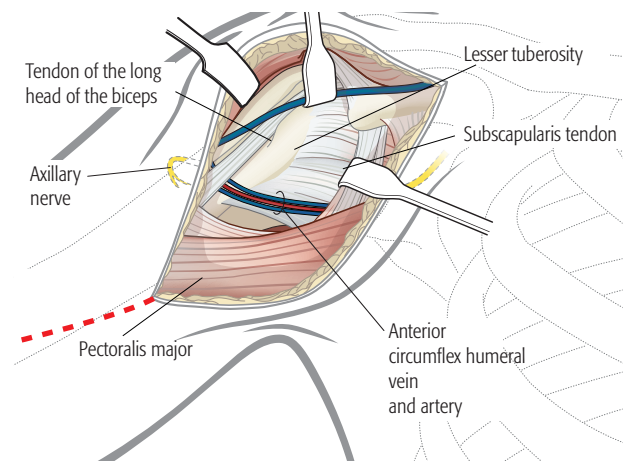


Exposure of the deep layers

Identify the coracoid process and the conjoint tendon. Incise the clavipectoral fascia lateral to the conjoint tendon and inferior the coracoacromial ligament.



Retract the deltoid muscle laterally using a delta (modified Hohmann) retractor and the conjoint tendon medially using a Langenbeck retractor.



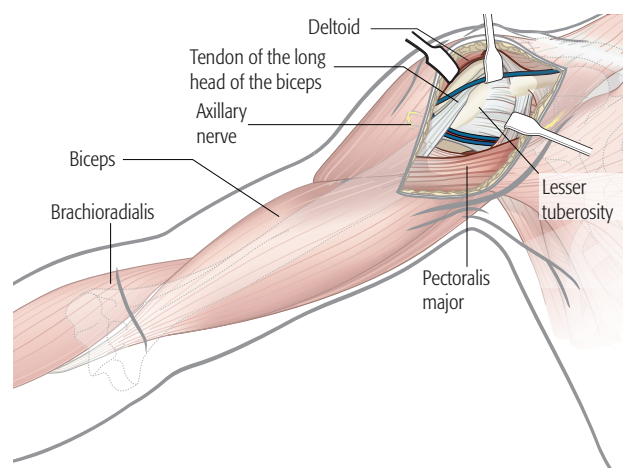
Exposure of the proximal humerus

Expose the main fragments of the fracture and the anatomical key structures such as

- Tuberosities
- Insertion of pectoralis major (latissimus dorsi and teres major)
- Insertion of the deltoid muscle
- Biceps
- Brachioradialis

Pitfall: axillary nerve damage

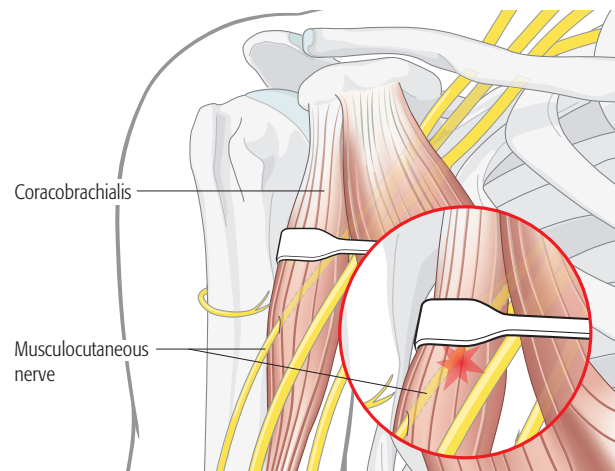
Be aware of retractor positioning (Roux or Hohmann retractor) to prevent iatrogenic damage of the axillary nerve.





Pitfall: neuropraxia of musculocutaneous nerve

The musculocutaneous nerve enters the coracobrachialis as close as 2.5 cm distal to the tip of the coracoid. Retractors placed under the conjoined tendon can cause neuropraxia; therefore, vigorous retraction must be avoided.



Pearls

- Using an additional delta retractor might be helpful to increase exposure of the proximal humerus.
- Exposure may be increased additionally by partially releasing the insertions of deltoid and/or pectoralis major.
- Shoulder abduction decreases tension on the deltoid and makes it easier to retract laterally.

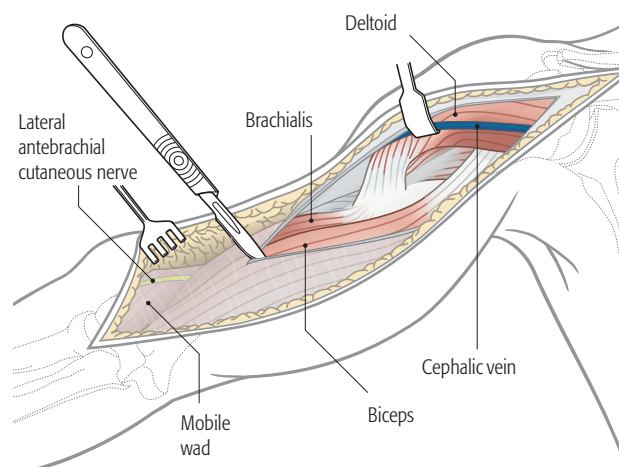
Distal extension of the deltopectoral approach

The deltopectoral approach can be extended distally as much as needed.

Superficial dissection

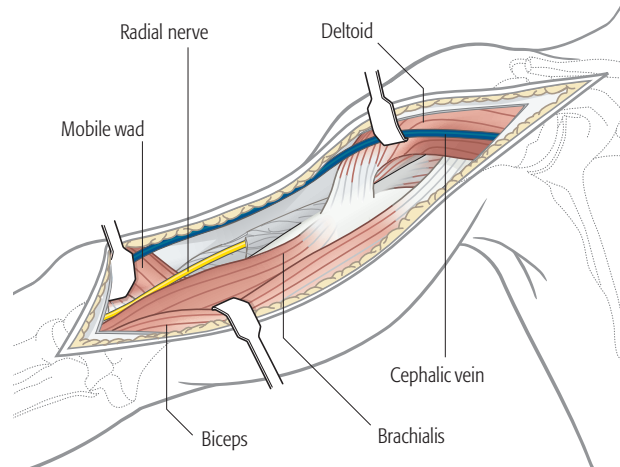
Extend the incision of the superficial fascia of the upper arm carefully between biceps/brachialis and the mobile wad distally.

Look for the lateral cutaneous nerve of the forearm crossing distally. The radial nerve is deeper. Identify the nerve in the interval between biceps and the mobile wad and follow it proximally as the incision is developed.





Retract the biceps medially, and the mobile wad laterally to identify the radial nerve. The brachialis is now exposed.

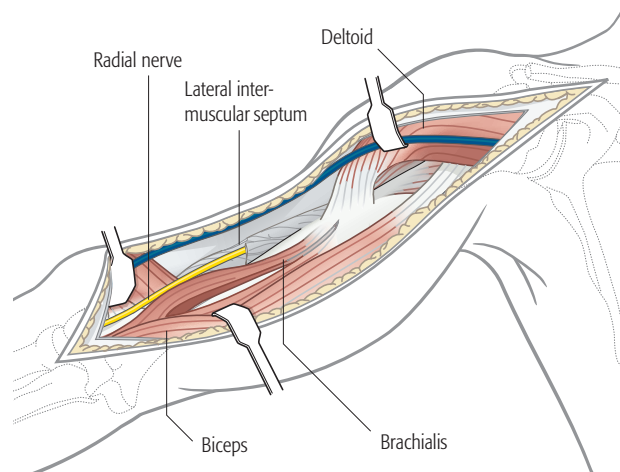


Deep dissection

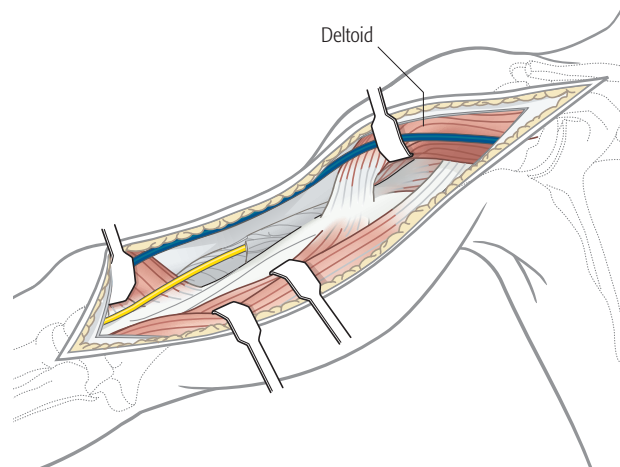
Dissect the brachialis within the neurovascular plane between the radial and the musculocutaneous nerves to maintain innervation of the brachialis.

If necessary release some of the muscle attachment proximally to allow the plate to lie on the bone.

Extend the dissection proximally, as needed, to the anterior border of the deltoid and along the deltopectoral interval.



Alternatively, the brachialis may be retracted medially. Beware that this injures the radial nerve branch to the brachialis.

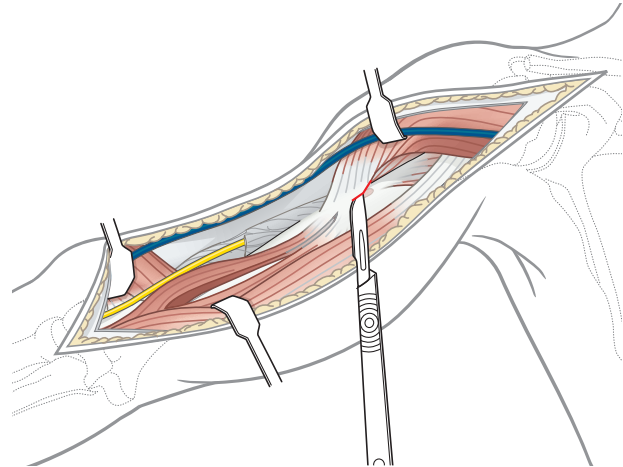




Partially release the deltoid insertion anteriorly, if necessary, and retract laterally to access the proximal humerus.

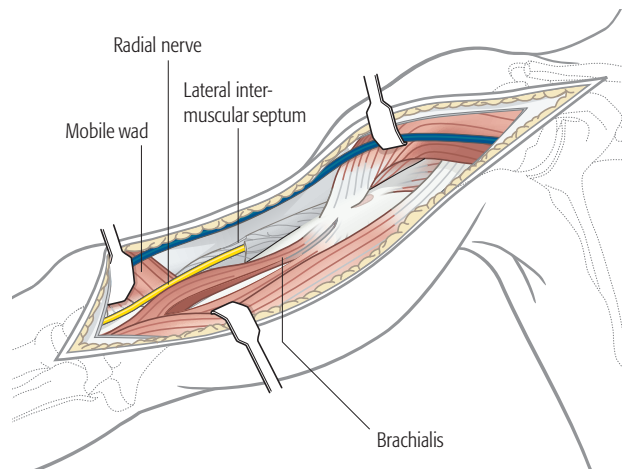
Alternatively dissect bluntly under the central deltoid insertion to allow for plate placement.

Leave as much muscle attached to bone as possible to preserve vascularity and reattach the released portion at the end of the procedure.



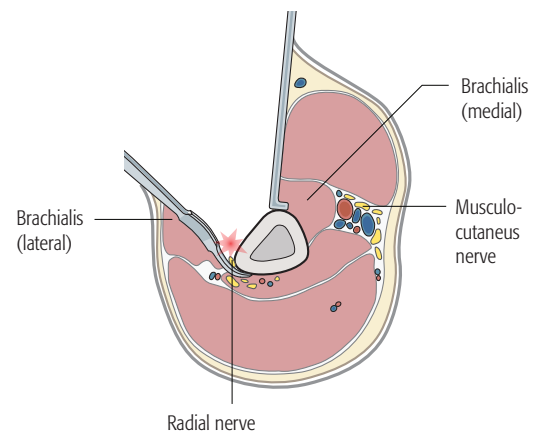
Distally, the anterior humerus has been exposed to the elbow joint, between the mobile wad and brachialis.

Mobilize the radial nerve, as needed, to access the bone. Follow the nerve to the point where it passes through the lateral intermuscular septum.



Pitfall: injury of the radial nerve

The radial nerve enters the anterior compartment by perforating the lateral intermuscular septum. The use of Hohmann retractors in the distal 2/5 of the humerus carries a high risk of iatrogenic nerve injury and should therefore be avoided.

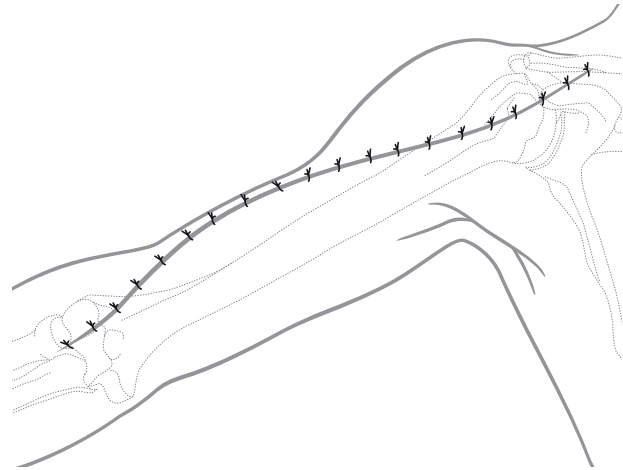




Wound closure

Irrigate the wound. Placement of a drain underneath the deltoid muscle might be considered.

Close the subcutaneous tissues and the skin in layers in a standard manner.

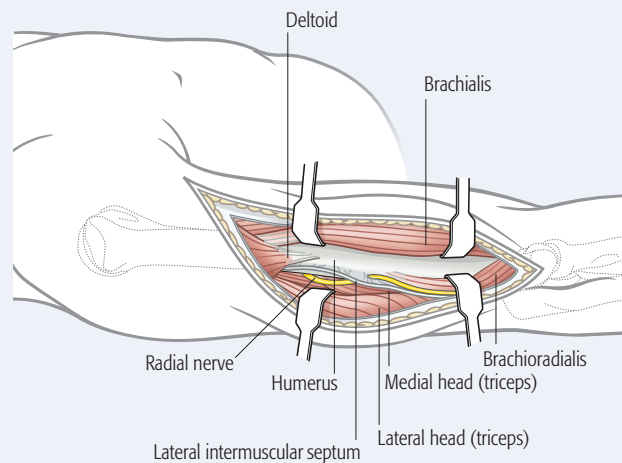




4.8 Lateral approach to the humeral shaft

Surgical approach

The lateral approach allows safe exposure of the distal two thirds of the humerus. It can be extended proximally also to expose the proximal humerus.



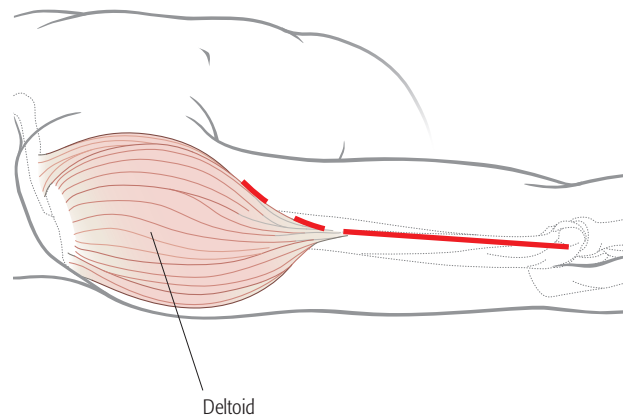
Introduction

The lateral approach allows safe exposure of the distal two thirds of the humerus. It can be extended proximally also to expose the proximal humerus.



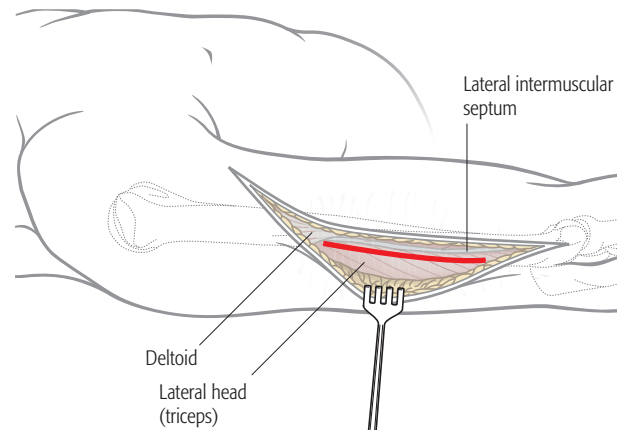
Skin incision

The incision follows a line from the deltoid insertion to the lateral epicondyle. It may be extended proximally along the anterior, or rarely posterior, margin of the deltoid.



Superficial dissection

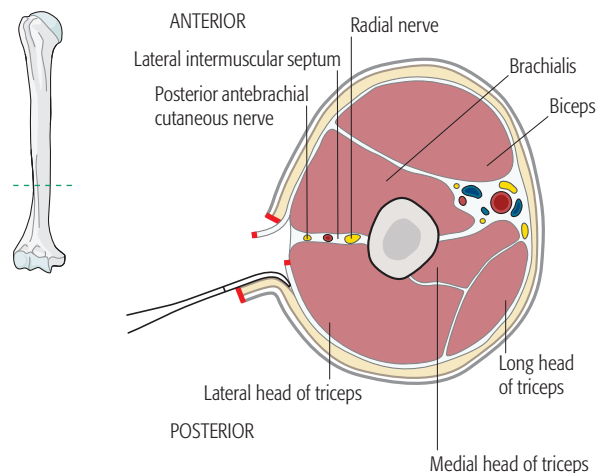
Elevate the posterior skin and subcutaneous tissue flap away from the deep fascia to ensure that the deep fascia over the triceps can be incised posterior to the lateral intermuscular septum.



Deep dissection

Elevate the anterior flap of the muscular fascia from the edge of the lateral intermuscular septum to prepare for later exposure of the anterior compartment of the arm.

At this stage of the approach it is important to enter the posterior compartment of the arm between the triceps muscle and the lateral intermuscular septum.



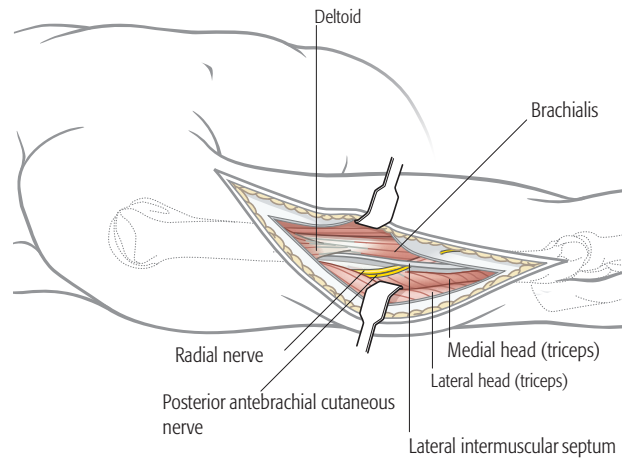


After entering the posterior compartment, find the posterior antebrachial cutaneous nerve, which can be followed proximally to the radial nerve. (Distally this cutaneous nerve passes through the fascia over brachioradialis.)

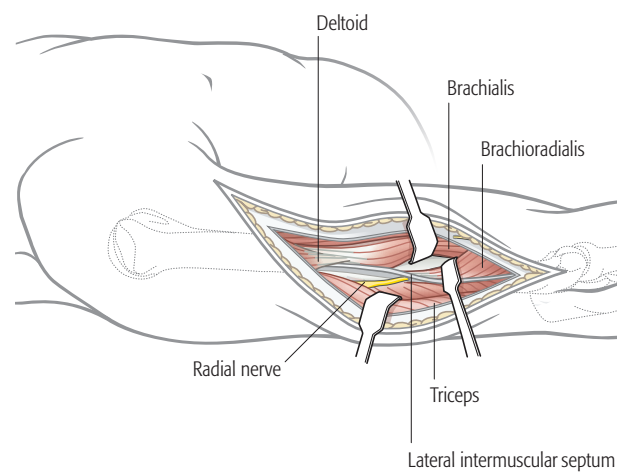
Develop the interval between the lateral intermuscular septum and triceps, distally to proximally.

In the middle third of the humerus find the radial nerve within fat immediately adjacent to the triceps.

Pearl: As a rough orientation, the radial nerve enters the anterior compartment between the distal and middle third of the humerus.

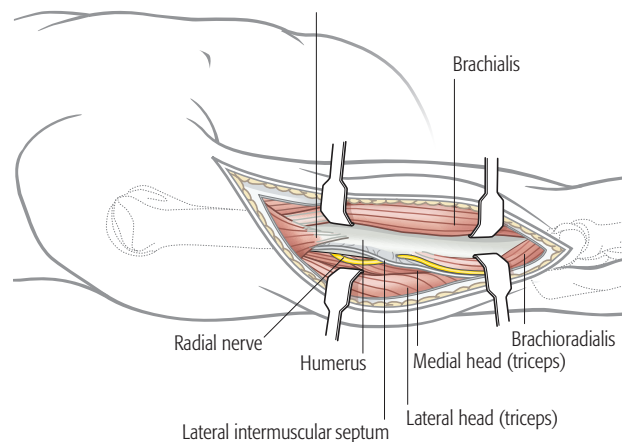


Distally, follow the radial nerve between brachialis and brachioradialis in the anterior compartment of the arm. Carefully retracting the nerve, expose the underlying humerus. Release the lateral intermuscular septum, as needed, for access to the bone and to mobilize the radial nerve.



Follow the radial nerve proximally, posterior to the humerus and anterior to the triceps.

This allows safe exposure of the distal two thirds of the humerus.

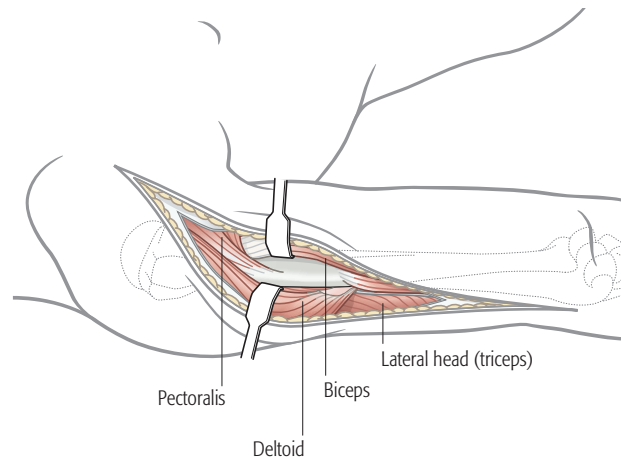




Proximal extension of the approach

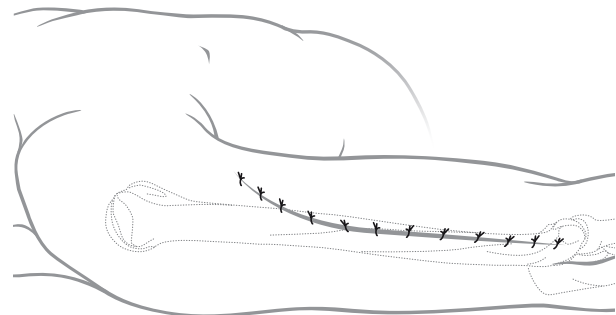
If necessary, extend the dissection proximally along the deltopectoral interval to access the proximal humerus. This does not allow access to the proximal part of the radial nerve.

Alternatively, extend the incision along the posterior deltoid and into the posterior compartment to follow the radial nerve, but the bone exposure is more limited.



Wound closure

Close the incision in layers in a standard manner.

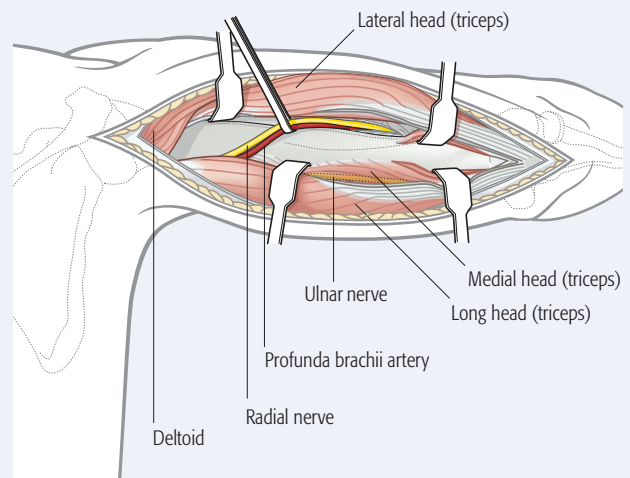




4.9 Posterior triceps-split approach

Surgical approach

This approach is most commonly used for fractures involving the distal half of the humerus. However, it can be extended for more proximal fractures once the radial nerve has been identified.



Introduction

This approach is most commonly used for fractures involving the distal half of the humerus. However, it can be extended for more proximal fractures once the radial nerve has been identified.

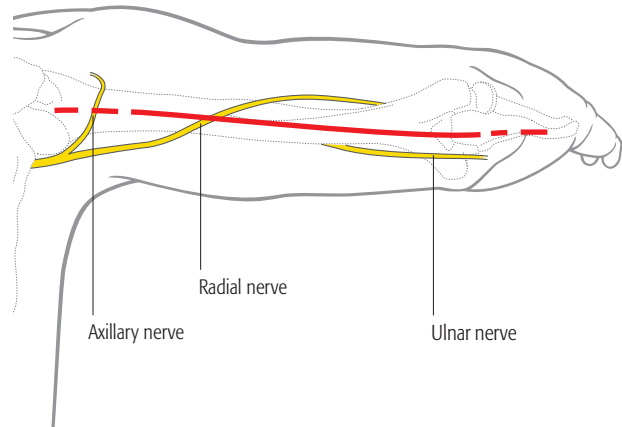


Skin incision

The complete incision is illustrated. Depending on the fracture and its location a smaller section might be used.

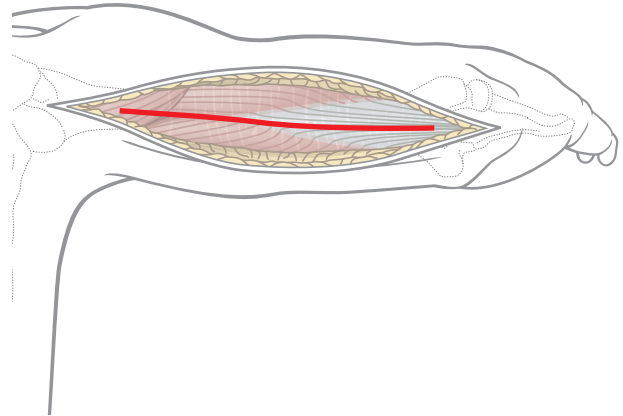
Incise the skin, beginning at the tip of the olecranon.

The incision runs proximally in a straight line along the posterior midline of the arm. It crosses the radial nerve in the mid-humeral region and the axillary nerve proximally.

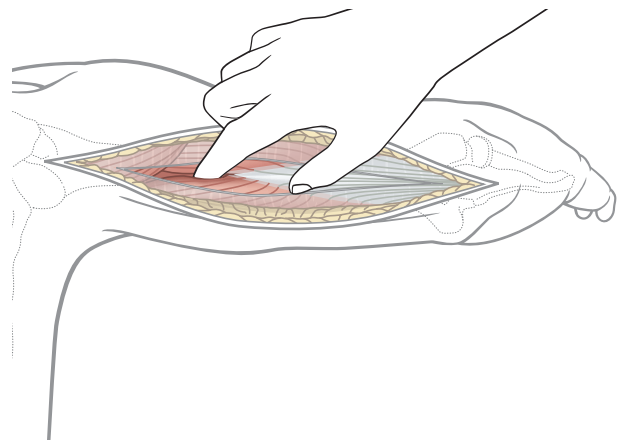


Superficial dissection

Incise the deep fascia in line with the skin incision.



By palpation with a finger, identify the interval between the lateral and long heads of the triceps. The opening of this interval will be developed from proximal to distal, remembering that the radial nerve lies beneath the triceps as it crosses the humerus.



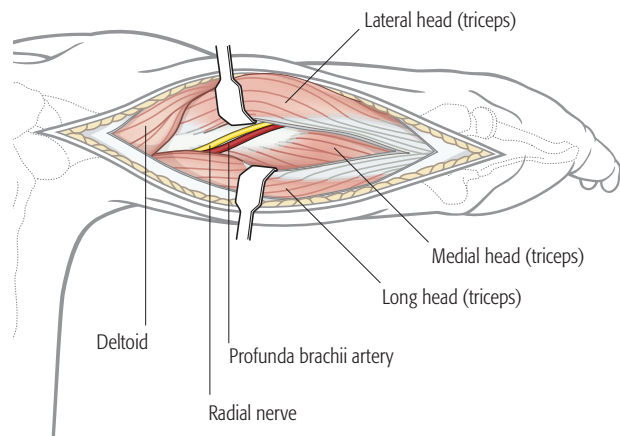


Deep dissection

Then develop the proximal interval between the two heads by dissection, retracting the lateral head laterally and the long head medially.

Within the spiral groove, identify the radial nerve and the accompanying profunda brachii artery.

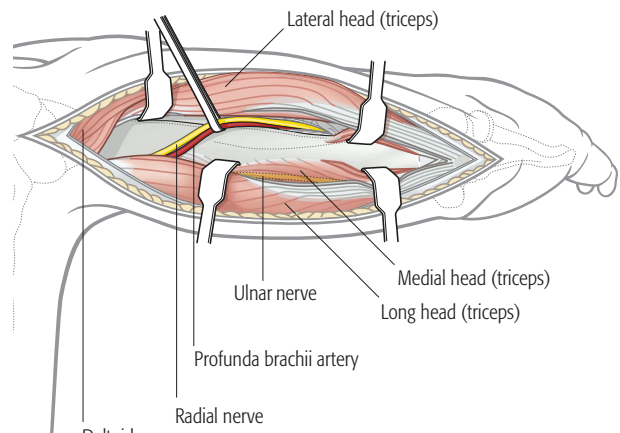
Distally, split the common triceps tendon, along the line of the skin incision, by sharp dissection.



Release the medial head of the triceps from the humerus proximally, and incise it distally, in line with the humeral shaft. Release the muscle from the bone only as much as needed and protect the ulnar nerve medially. The ulnar nerve is constrained at the point where it passes distally through the medial intermuscular septum, from the anterior to the posterior compartment of the arm.

Release the medial head of the triceps proximally until the axillary nerve is found.

Now the posterior humerus, crossed by radial nerve and its accompanying vessels, lies exposed from the axillary nerve and posterior circumflex humeral artery proximally to the capitellum distally.



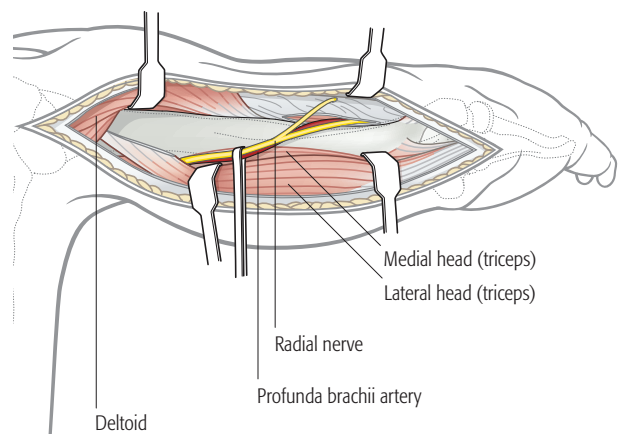
Extending the approach

Distal extension

Splitting the triceps tendon limits distal exposure, which can be improved by approaching the humerus from the lateral side of this muscle. For more details see the distal posterior approach.

Proximal extension

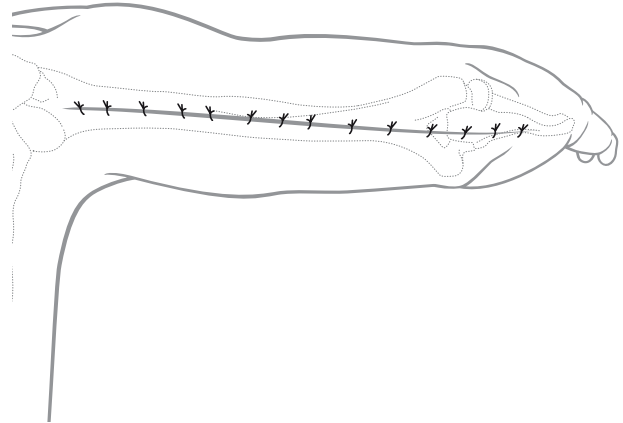
Limited proximal extension, even beyond the axillary nerve, is possible with careful mobilization and retraction of both radial and axillary nerves and their accompanying vessels.





Wound closure

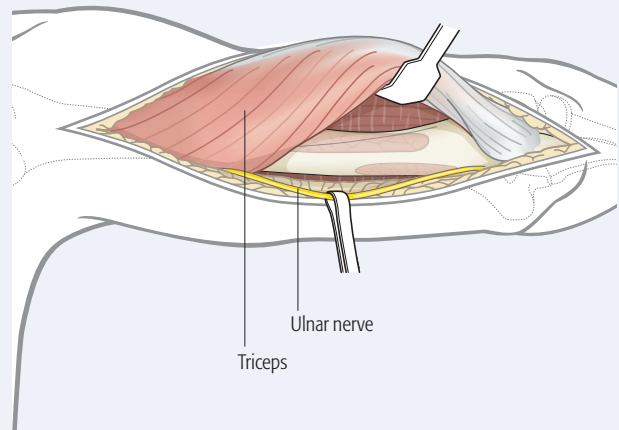
Close the wound in layers in a standard manner.



4.10 Posterior triceps-sparing approach (triceps-on)

Surgical approach

For midshaft and distal shaft fractures, the posterior approach may be extended distally, leaving the triceps insertion intact. This provides adequate exposure for reduction and fixation.

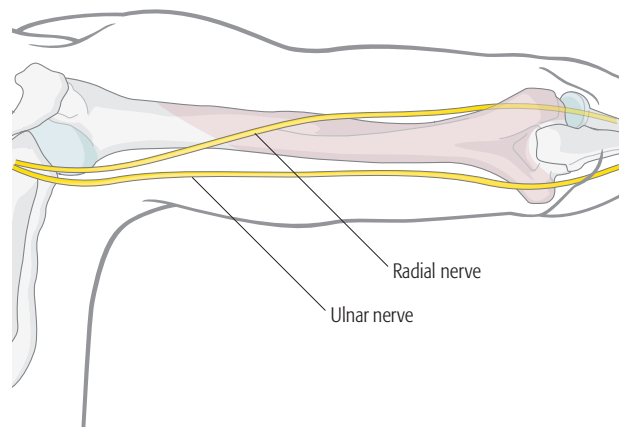


Introduction

For midshaft and distal shaft fractures, the posterior approach may be extended distally, leaving the triceps insertion intact. This provides adequate exposure for reduction and fixation.

The triceps is elevated off the posterior humerus, but its insertion is not disturbed.

This retains the musculotendinous integrity of the triceps and allows more rapid postoperative rehabilitation.



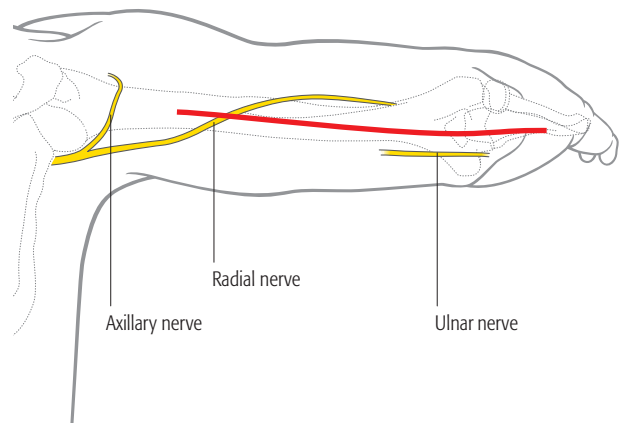


Skin incision

The complete incision is illustrated. Depending on the fracture and its location a smaller section might be used.

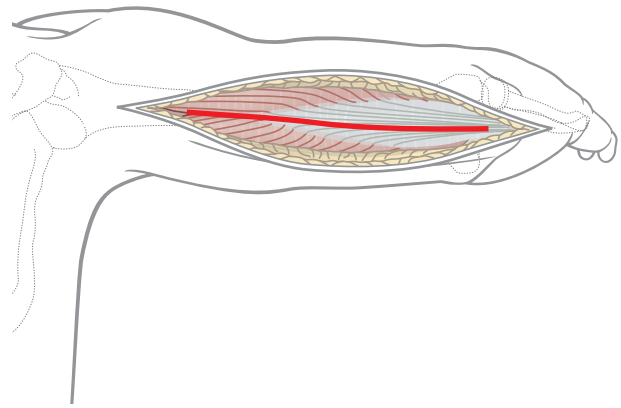
Incise the skin, beginning at the tip of the olecranon.

The incision runs proximally in a straight line from the olecranon along the posterior midline of the arm. It crosses the radial nerve in the mid-humeral region and the axillary nerve proximally.



Superficial dissection

Incise the deep fascia in line with the skin incision.



Ulnar window

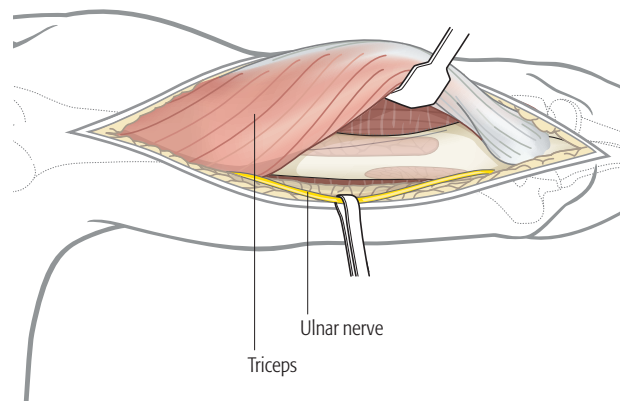
As a first step, identify and mobilize the ulnar nerve. It may be helpful to protect it with a vessel loop.

Proximally, follow the ulnar nerve along its course on the medial intermuscular septum.

Note: Take care that the protecting vessel loop does not injure the ulnar nerve by uncontrolled traction. Do not use heavy clamps to secure the loop.

Next, mobilize the triceps muscle and retract it laterally. This may be achieved by bluntly dissecting the medial head of the triceps from the posterior aspect of the humerus.

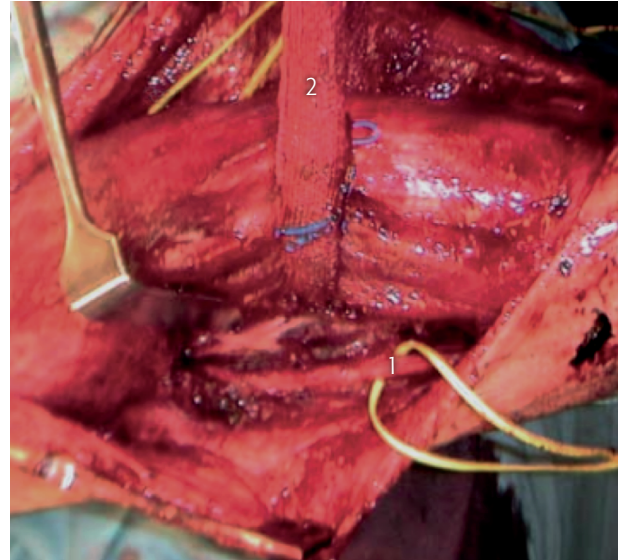
Depending on the fracture location the exposure may need to be extended distally.





In the case shown here, going up into the diaphysis, the ulnar nerve was identified and held with a vessel loop (1).

The entire triceps muscle is isolated with a gauze wrap (2).

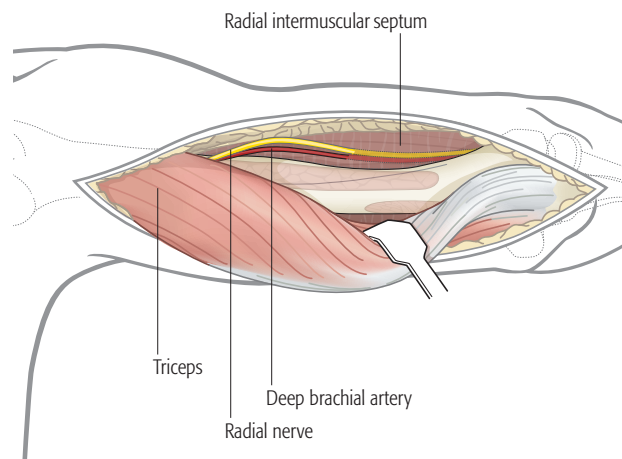


Radial window

Split the triceps fascia and mobilize the lateral head of the triceps from the lateral intermuscular septum and humerus towards the ulnar side.

If necessary dissect remaining muscle fibers, still attached to the posterior aspect of the humerus, from the lateral side. This ends up in a liberated muscle complex containing the long head, lateral head and the medial head of the triceps. This permits the whole triceps muscle to be moved towards either the lateral or medial side, to provide access to the humerus ("triceps flip").

The radial nerve can be detected at its penetration through the intermuscular septum and followed upwards in the radial groove.





Wound closure

Close the wound in layers in a standard manner.

