Martin Jaeger | Frankie Leung | Wilson Li

3 Proximal humerus

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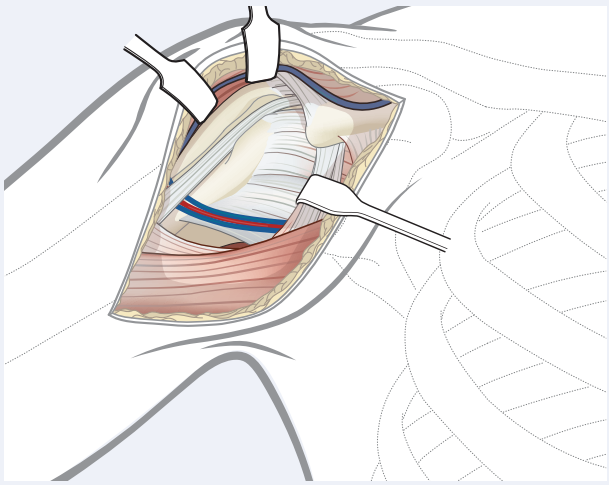
Executive Editor: **Peter Trafton**
Authors: **Martin Jaeger, Frankie Leung, Wilson Li**

3.1 Deltopectoral approach to the proximal humerus

Preliminary remark

The (anterior) deltopectoral approach can be used for almost any proximal humeral fracture treatment and is often the preferred approach. This approach is also highly recommended for revision surgery.

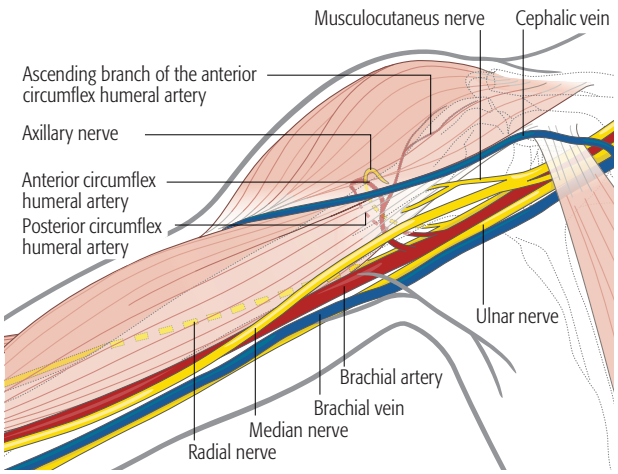


Anatomy

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

- Cephalic vein
- Anterior circumflex humeral artery
- Ascending branch of the anterior circumflex humeral artery
- Posterior circumflex humeral artery
- Musculocutaneus nerve
- Axillary nerve
-

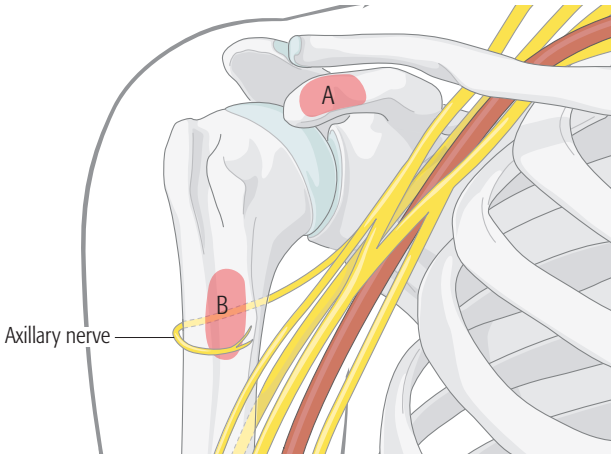
Further neurovascular structures, eg the brachial plexus, are only at risk if there is a rigorous retraction.



Anatomical landmarks

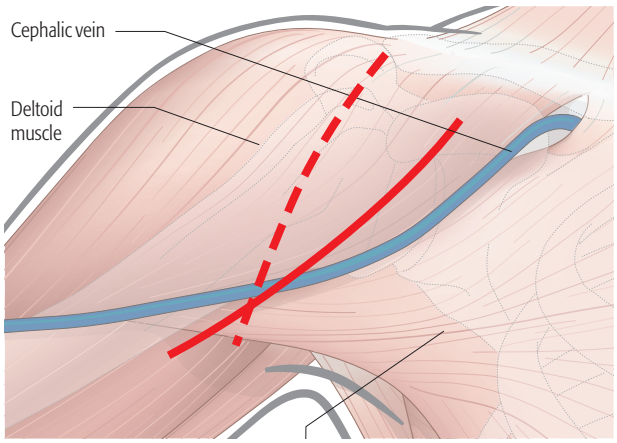
Anatomical landmarks for the anterior deltopectoral approach are:
A) Coracoid process
B) Proximal humeral shaft (on the level of the axilla)

Both landmarks can easily be palpated.



Skin incision

Make a 12-14 cm long skin incision between the coracoid process and the proximal humeral shaft. The shape of the skin incision can be straight or curved depending on surgeon's preference.
For an arthroplasty for degenerative diseases, a rather vertical incision may be preferred (dashed line).

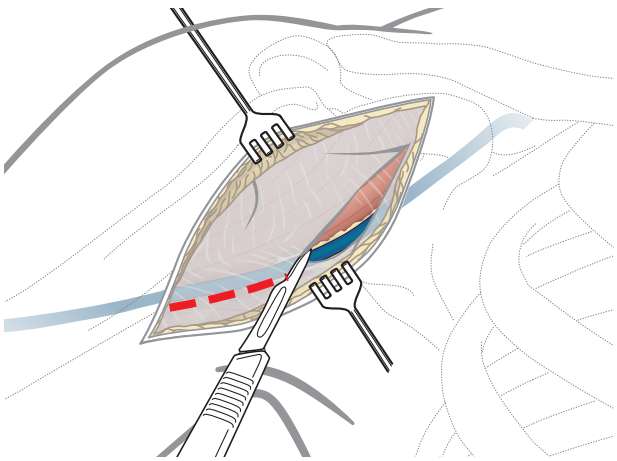


Exposure of the superficial fascia

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

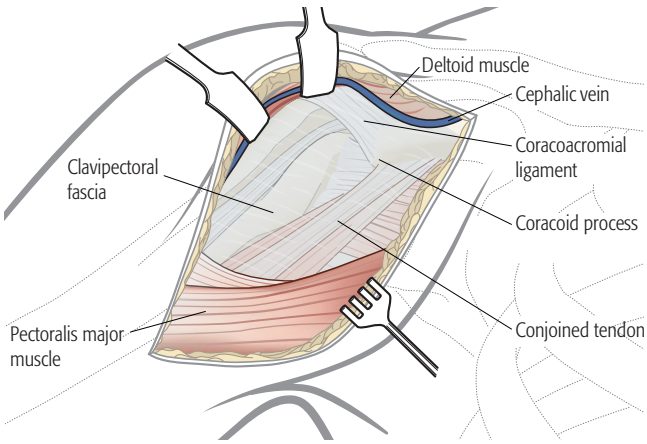
- The course of the muscle fibers
- The cephalic vein itself
- Fat tissue surrounding the vein
-

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 scared.)



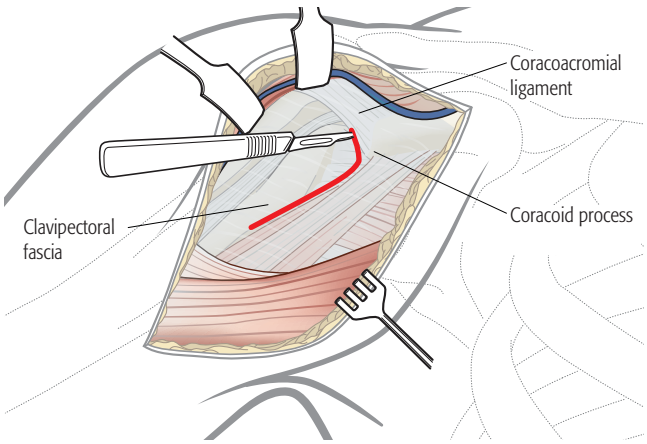
Dissection down to the deltopectoral groove

Retract the cephalic vein laterally or medially, 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, the cephalic vein should be preserved 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 conjoined tendon.
Incise the clavipectoral fascia lateral to the conjoined tendon and inferior the coracoacromial ligament.

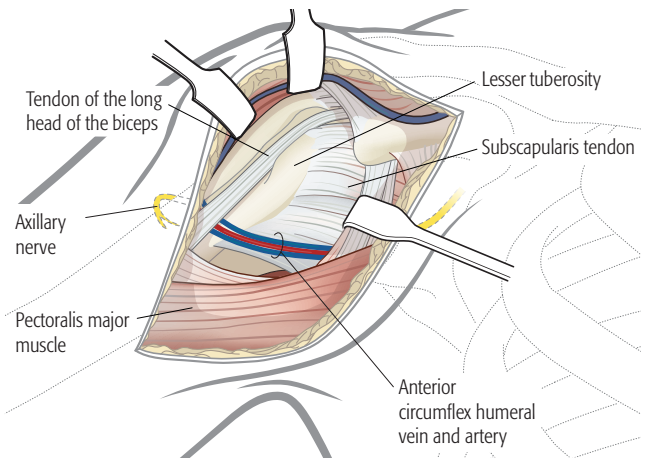


Retract the deltoid muscle laterally using a delta (modified Hohmann) retractor and the conjoined tendon medially using a Langenbeck retractor.

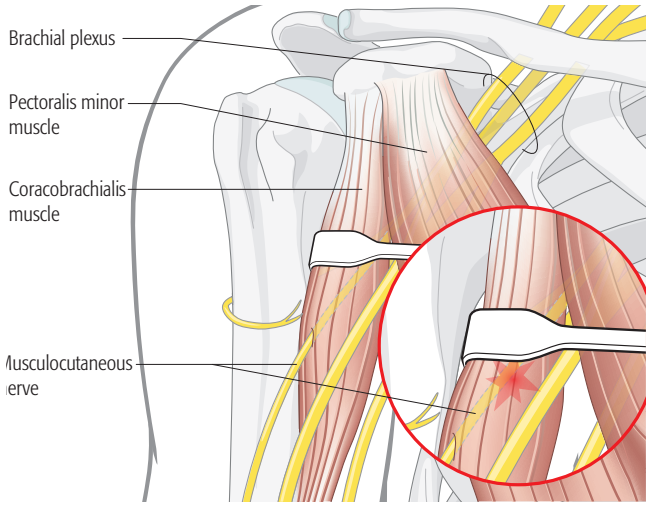
Expose the proximal humerus and confirm the anatomical landmarks (subscapularis tendon, lesser tuberosity, bicipital groove with the biceps tendon and the greater tuberosity). Evaluate the fracture morphology. Hemorrhagic bursa tissue has to be resected if needed.

Distally, expose the pectoralis major.

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



Pitfall: The musculocutaneous nerve enters the coracobrachialis muscle 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.

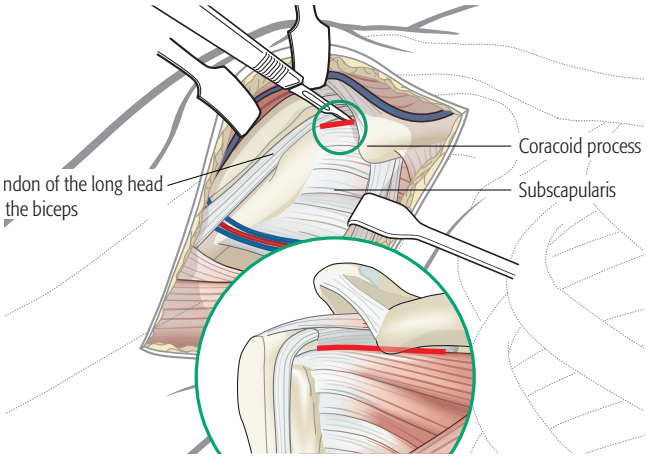
Intraarticular exposure

There are several ways to expose the intraarticular aspect of the glenohumeral joint:

- Incision of the rotator interval
- Opening through the fracture (dislocation of the lesser tuberosity fragment)
- Tenotomy of the subscapularis tendon

Incision of the rotator interval

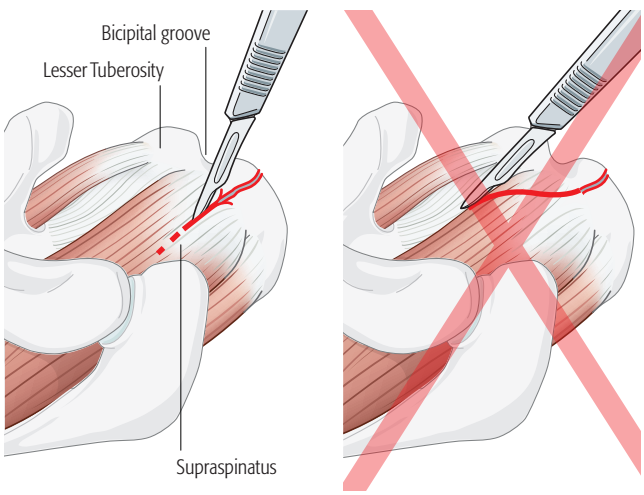
Identify the course of the long head of the biceps and the upper border of the subscapularis tendon. Incise the rotator interval just at the upper border of the subscapularis tendon towards the coracoid process. It might be helpful to perform a tenotomy of the long head of the biceps close to the labrum and to remove the intraarticular portion of the biceps. This window creates a nice view to the anterosuperior parts of the humerus. It does not violate the function of the rotator cuff.



Pitfall: In fractures of the proximal humerus which consist of an anterior fragment one should take care to analyze the fracture pattern. If the anterior fragment consists of the lesser tuberosity, the bicipital groove and the anterior part of the greater tuberosity, it is strongly recommended to use a supraspinatus split in line of the fracture instead of the incision of the rotator interval.

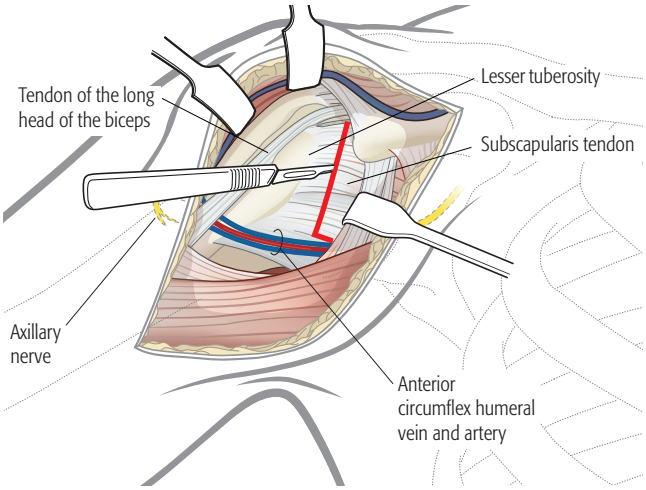
Opening through the fracture

In fractures of the proximal humerus which consist of a lesser tuberosity fragment, it might be beneficial to open up the joint through the fracture between the greater and lesser tuberosity. Take care that the extension of the vertical fracture line between the tuberosities typically runs into the supraspinatus tendon and not into the rotator interval. Therefore, a split of the supraspinatus tendon is necessary to preserve the anterior insertion of the supraspinatus tendon.

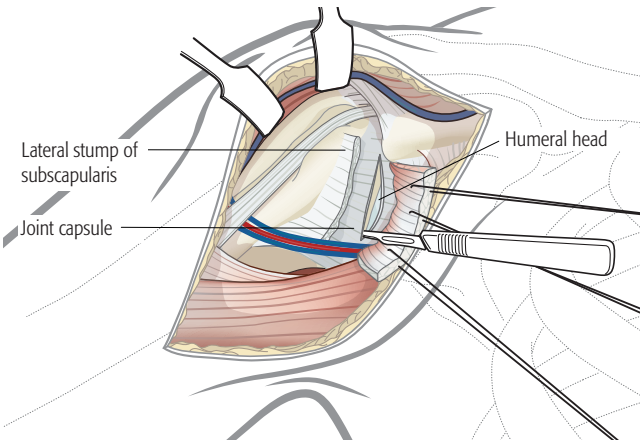


Tenotomy of the subscapularis tendon

Satisfactory reduction of anatomical neck fractures may sometimes require an anterior shoulder arthrotomy. The subscapularis tendon is identified and divided vertically lateral to the musculotendinous junction in line of the anatomical neck.

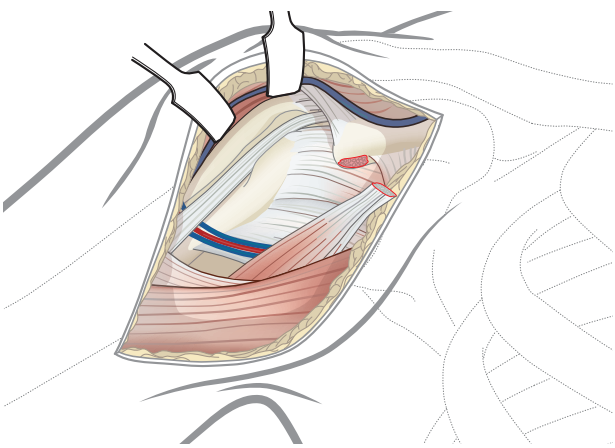


Reflect the subscapularis from the underlying joint capsule and enter the joint through a vertical capsulotomy, medial to the lateral stump of the subscapularis.



Tenotomy of the conjoined tendon/osteotomy of the tip of the coracoid process

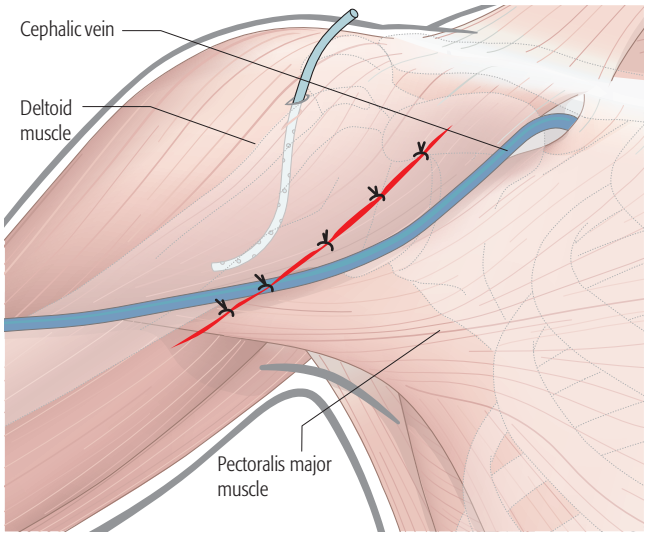
If difficulty is encountered in trying to expose the axillary nerve, for example in a revision procedure following a previous attempt at fixation, it may be helpful to develop the course of the axillary nerve starting from unoperated tissues. This may be facilitated by reflecting the conjoined tendon from the tip of the coracoid, or with a small coracoid osteotomy.



Wound Closure

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

Close the deltopectoral groove, the subcutaneous tissues and the skin.



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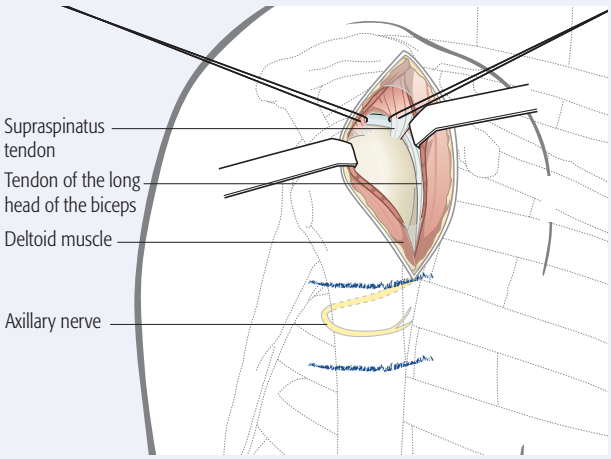
3.2 Anterolateral approach

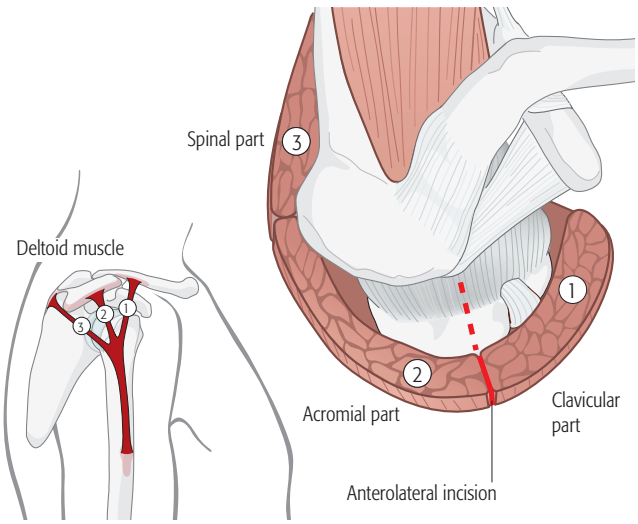
Preliminary remark

The anterolateral (acromial) approach (Mackenzie) can be used for various treatments of proximal humeral fractures. It is especially useful for nailing and osteosynthesis of fractures of the greater tuberosity. It is also recommended for minimally .



Indication

The anterolateral (acromial) approach (Mackenzie) can be used for various treatments of proximal humeral fractures. It is especially useful for nailing and osteosynthesis of fractures of the greater tuberosity. It is also recommended for minimally invasive plate osteosynthesis (MIPO).
This incision is placed between the clavicular part (1) and acromial part (2) of the deltoid muscle, as illustrated. Depending on the fracture morphology and foreseen osteosynthesis the extensions of the skin incision may vary but may not extend more than 5 cm distally to the acromion, to protect the axillary nerve.

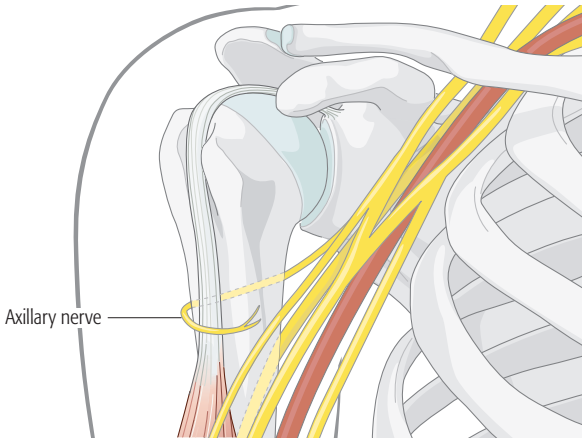


Anatomy

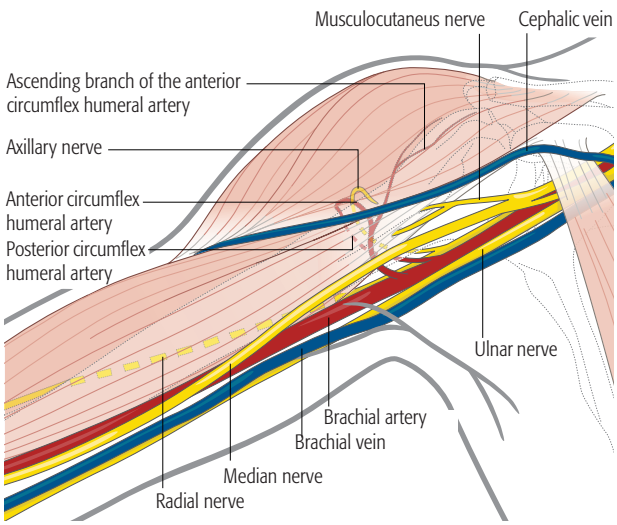
Neurovascular structures

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 significantly vary and is reliable.



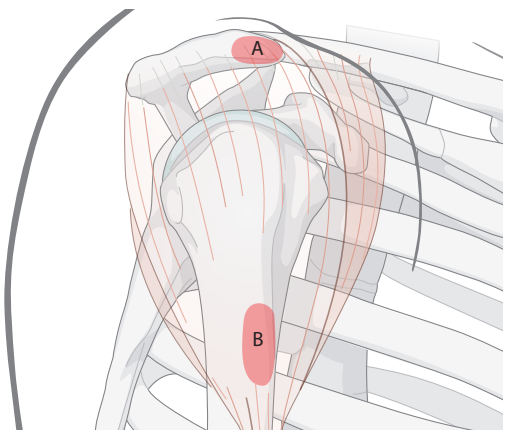
This approach utilizes a relatively avascular plane, away from the anterior and posterior circumflex humeral arteries.



Skin incision

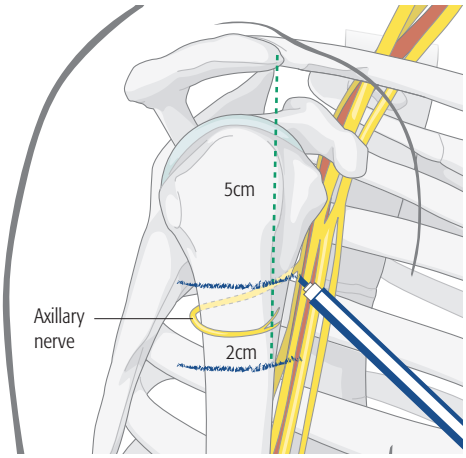
Anatomical landmarks

Anatomical landmarks for the anterolateral approach are:
A) Anterolateral edge of the acromion
B) Lateral side of the proximal humeral shaft
Both landmarks can easily be palpated.



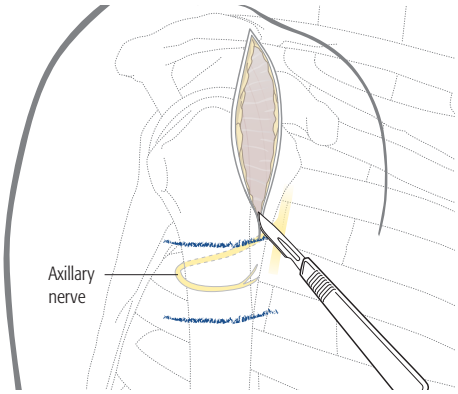
Axillary nerve

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.
If a plate is to be passed underneath the axillary nerve, as in minimally invasive plate osteosynthesis (MIPO), 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 anterior border of the acromion for 5 cm distally, parallel to the axis of the humerus.



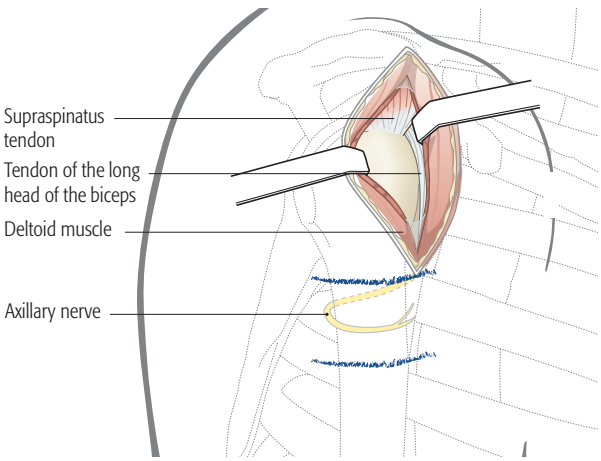
Exposure of the anteromedial raphe

Expose and dissect the raphe of the deltoid muscle between the anterior and medial portion of its fibers. Split the raphe, in line with the deltoid fibers, to obtain a fairly avascular approach to underlying structures.

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.

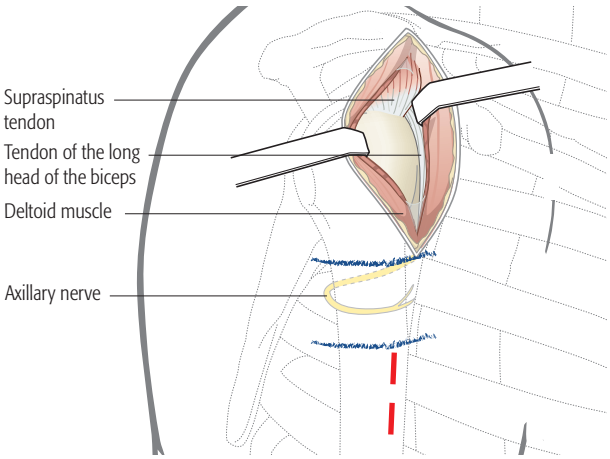


Pearl: stay suture

In order to protect the axillary nerve from uncontrolled distal dissection, a stay suture may be placed at the inferior border of the deltoid raphe.

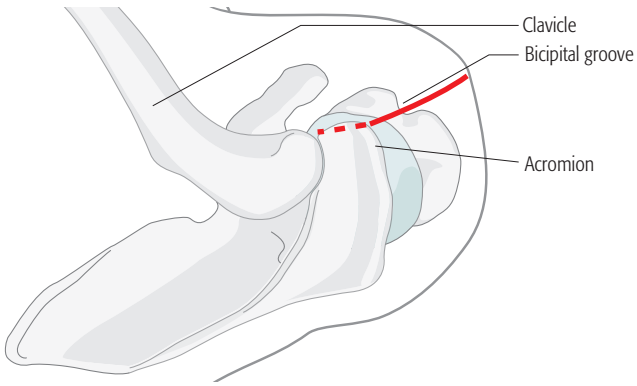
Additional stab incision for minimally invasive plate osteosynthesis (MIPO)

Safely below the marked (blue lines) axillary nerve, stab incisions may be made for screws to fix a plate to the humeral shaft. A special aiming device may be available for this purpose.

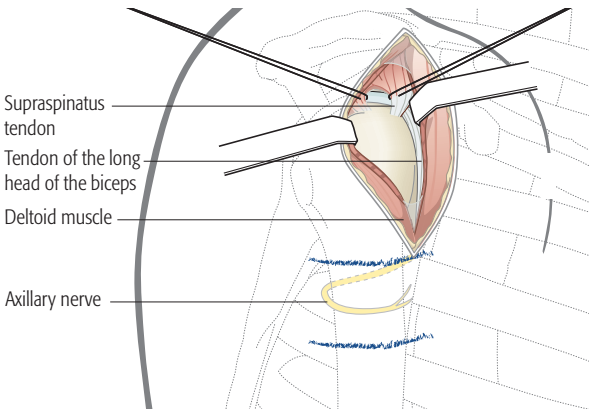


Exposure for intramedullary nailing

When the anterolateral approach is used for intramedullary nailing, a shorter skin incision may suffice. The length of the skin incision depends on fracture complexity.



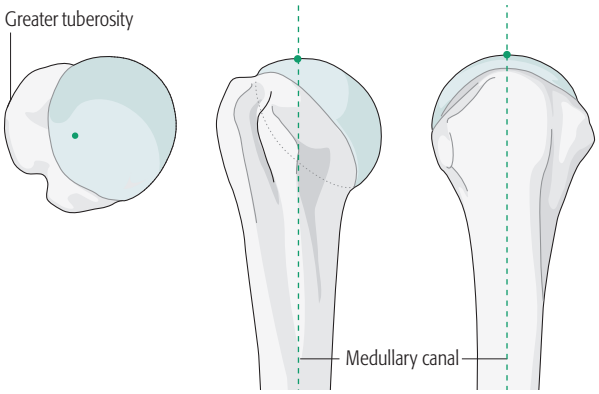
Prior to nail insertion, define the supraspinatus tendon by dissecting hemorrhagic subacromial bursa. Identify the tendon at its insertion. Make a short incision in line with its fibers and place stay sutures on each side of the insertion. Remember that the correct entry site lies deep to the tendon insertion and can only be accessed through the tendon. In less complex cases with only slight fragment displacement and where reduction can be performed in a closed manner, the nail can be inserted through a minimal skin incision. In these cases, sutures can be omitted, however, they help to protect the tendon edges during nail insertion.



Through the split in the supraspinatus tendon, slightly expose the cartilage of the humeral head medial to the greater tuberosity. Avoid the tendon of the long head of the biceps.

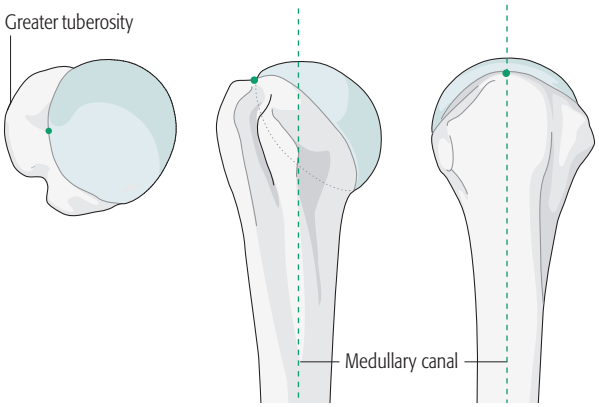
Entry point for straight nails

The ideal entry point is located in straight line with the axis of the medullary canal. One can find the correct entry point medial to the greater tuberosity, typically at the highest point of the humeral head slightly posterior to the bicipital groove. Insert a guide pin in this location.



Entry point for bent nails

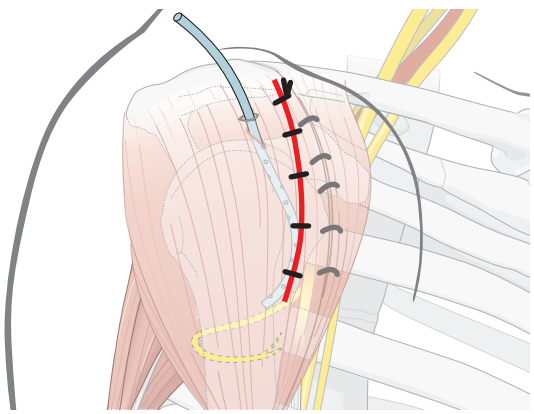
The ideal entry point is usually located just medial to the greater tuberosity, slightly lateral to the axis of the medullary canal on the AP view and in line with humeral axis on the lateral view. Insert a guide pin in this location.



Wound closure

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

Close the anteromedial raphe, the subcutaneous tissues, and the skin.



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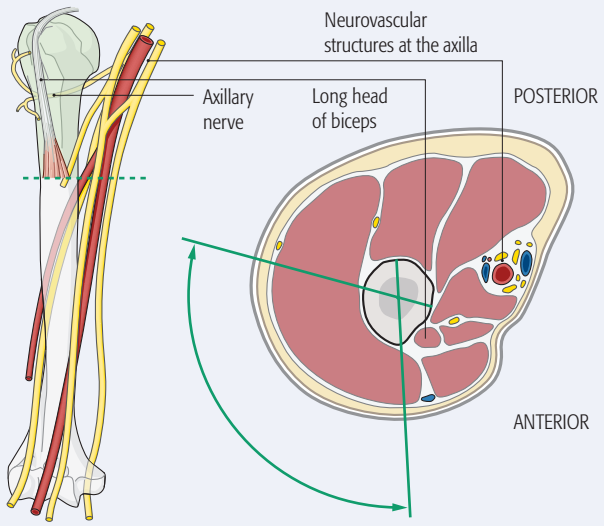
3.3 Safe Zones

Preliminary remark

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

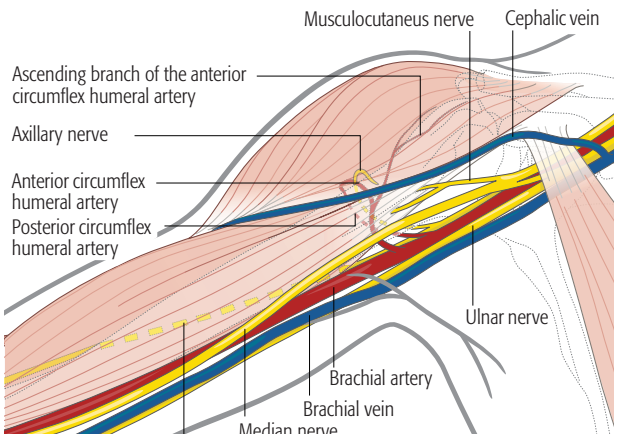


Anatomy

Neurovascular structures

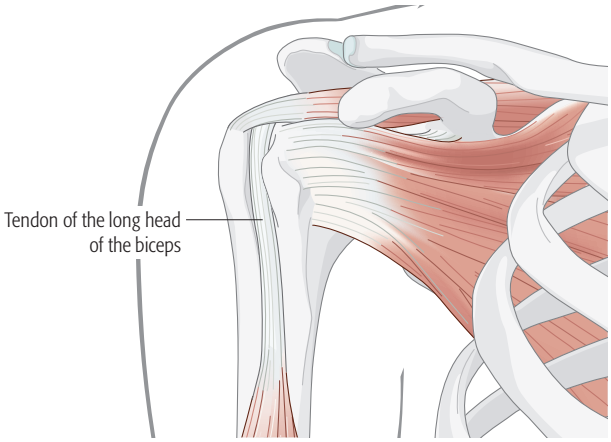
The course of the following neurovascular structures should be kept in mind:

- Axillary nerve
- Cephalic vein
- Anterior circumflex humeral artery
- Ascending branch of the anterior circumflex humeral artery
- Posterior circumflex humeral artery
- Musculocutaneus nerve



Tendon of the long head of the biceps

Another important structure is the tendinous origin of the long head of the biceps, which runs anteriorly and is usually palpable. Make sure not to fix this structure to the bone with pins or K-wires.



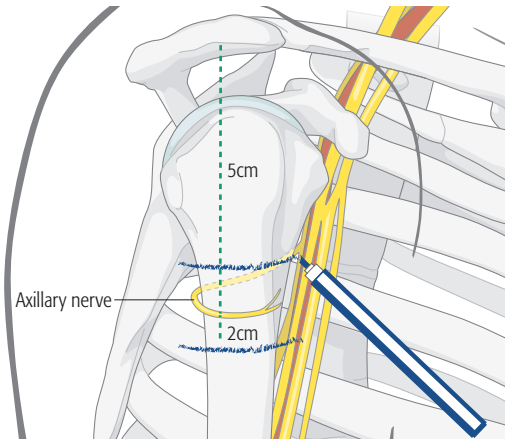
Safe zones

Axillary nerve

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 significantly vary and is reliable.

To protect the axillary nerve mark the skin 5 cm and 7 cm distally to the acromion. This marks the corridor in which the axillary nerve is at risk.

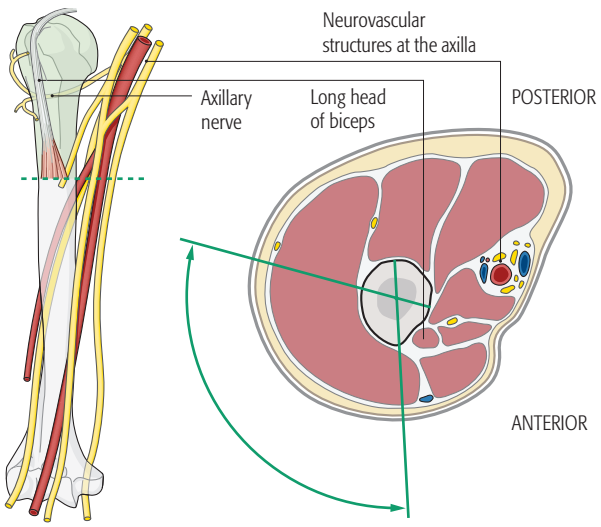
The lateral aspect of the proximal humerus, proximal and distal to this corridor can be regarded as a safe zone.



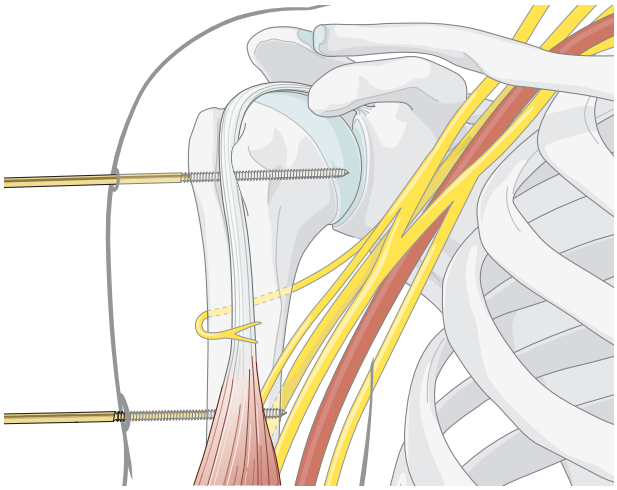
Pin insertion

Safe zones for pins

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



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



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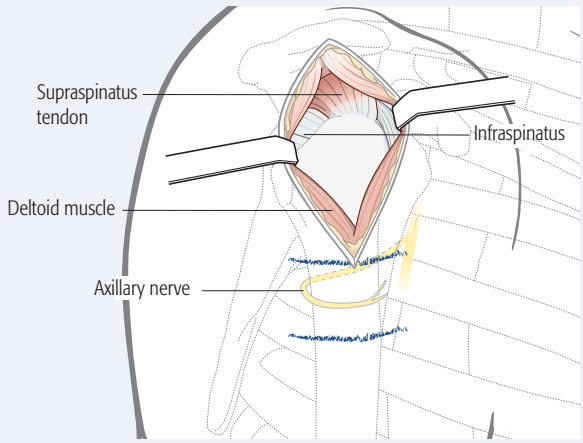
3.4 Transdeltoid lateral approach

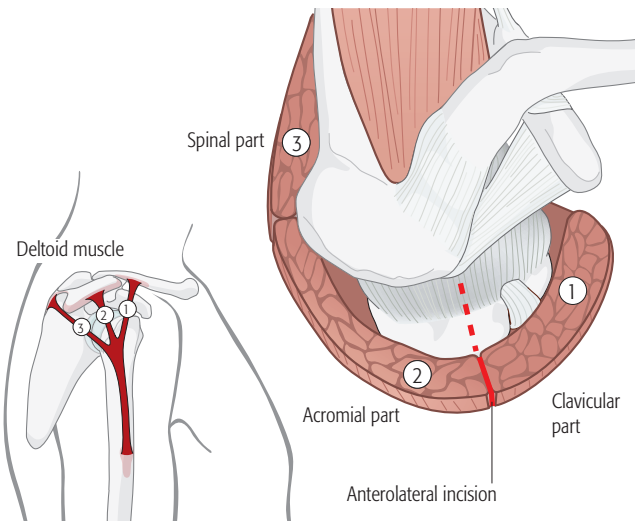
Preliminary remark

The transdeltoid lateral approach can be used for various treatments of the proximal humeral fractures.
It is especially useful for osteosynthesis of fractures of the greater tuberosity.



Indications

The transdeltoid lateral approach can be used for various treatments of the proximal humeral fractures.
It is especially useful for osteosynthesis of fractures of the greater tuberosity.
This incision is placed between the acromial part (2) and the spinal part (3) of the deltoid muscle, as illustrated.
Depending on the fracture morphology and foreseen osteosynthesis the extensions of the skin incision may vary but may not extend more than 5 cm distally to the acromion, to protect the axillary nerve.

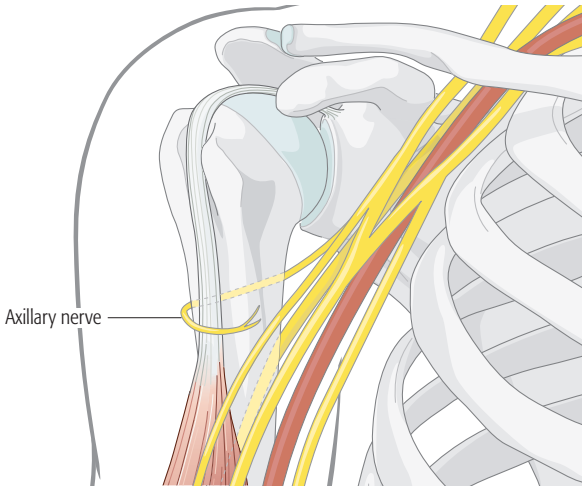


Anatomy

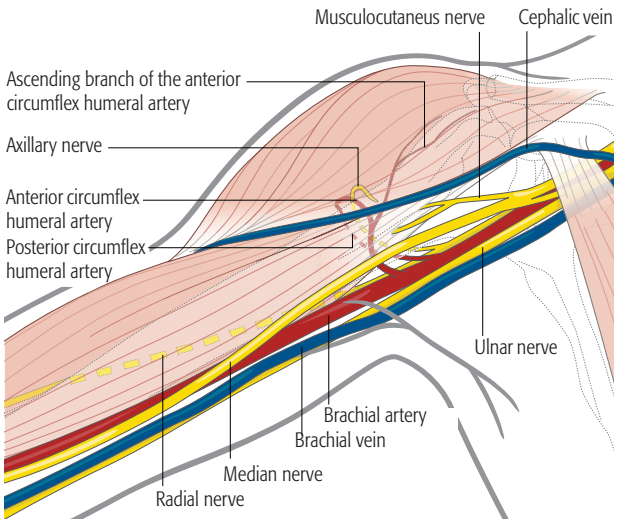
Neurovascular structures

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 significantly vary and is reliable.



This approach utilizes a relatively avascular plane, away from the anterior and posterior circumflex humeral arteries.



Skin incision

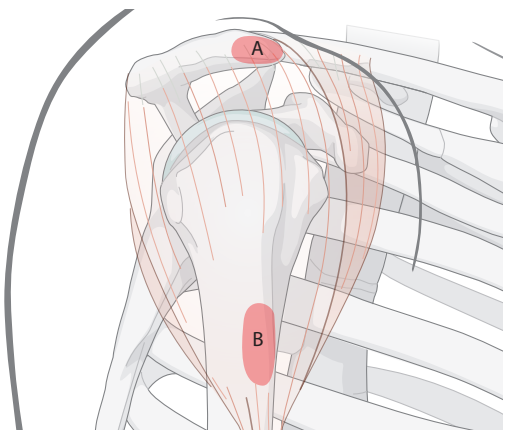
Anatomical landmarks

Anatomical landmarks for the transdeltoid lateral approach are:

A) Lateral border of the acromion

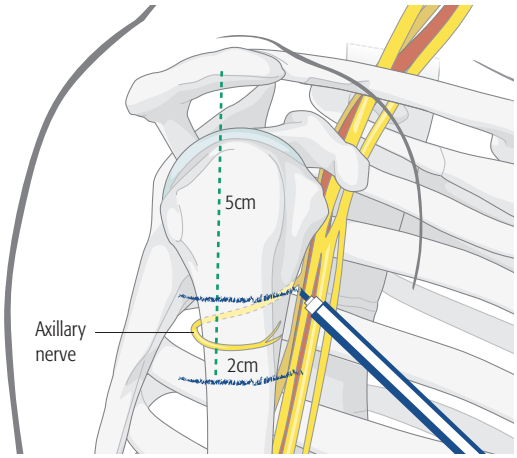
B) Lateral side of the proximal humeral shaft

Both landmarks can easily be palpated.



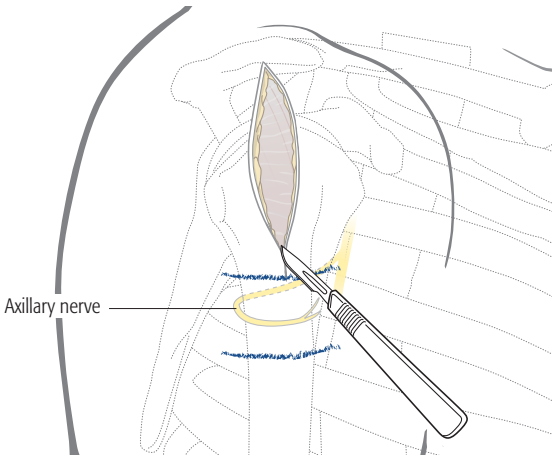
Axillary nerve

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.
If a plate is to be passed underneath the axillary nerve, as in minimally invasive plate osteosynthesis (MIPO), 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.



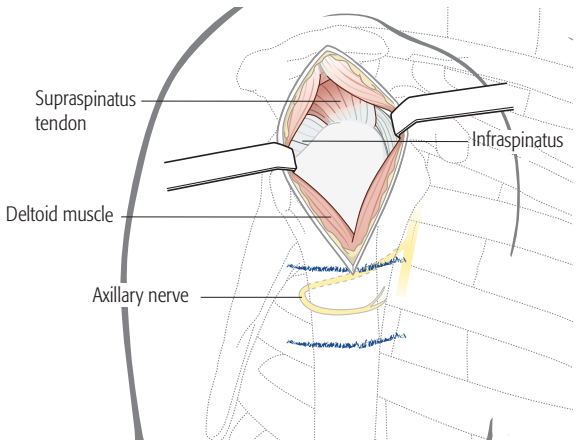
Skin incision

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



Exposure of the middle third part of the deltoid muscle

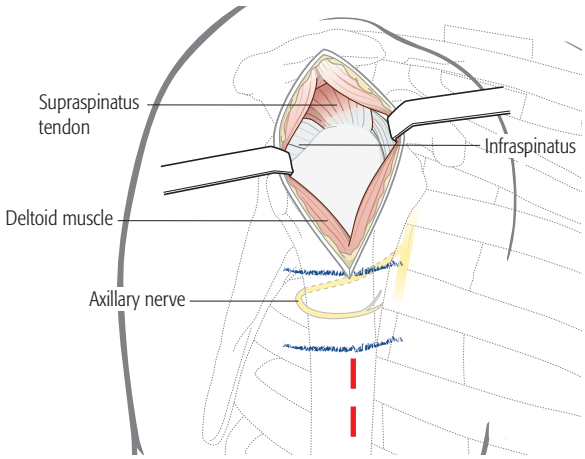
Expose the middle third (acromial) part of the deltoid muscle and split the muscle between its fibers.
For maximum exposure, split the deltoid up to the margin of the acromion, but do not split it distally more than 5 cm from its origin to avoid damaging the axillary nerve and paralyzing the anterior 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: stay suture In order to protect the axillary nerve from uncontrolled distal dissection, a stay suture may be placed at the inferior border of the deltoid split.

Additional stab incision for minimally invasive plate osteosynthesis (MIPO)

Safely below the marked (blue lines) axillary nerve, stab incisions may be made for screws to fix a plate to the humeral shaft. A special aiming device may be available for this purpose.



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.