Practical Procedures in Orthopaedic Trauma Surgery

Edited by
Peter V. Giannoudis and
Hans-Christoph Pape

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Practical Procedures in Orthopaedic Trauma Surgery

A Trainee's Companion

This highly illustrated textbook provides an essential guide for surgeons in training. It follows a step-by-step approach to performing a surgical procedure. It includes details of positioning the patient, the approach and reduction technique, the implant to be inserted, protocols for post-operative mobilisation, complications to look for, when the patient should be seen in the outpatient clinic and whether the implant should be removed. Intraoperative pictures have been incorpoated to make the surgeon aware of all the important issues involved. It covers the most common trauma procedures that surgeons in training are expected to perform during their residency. Each procedure has been written by an expert. This will be an invaluble resource for the resident in training during the long on-call nights in the hospital while preparing for the operations necessary to help trauma patients.

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A Trainee's Companion

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To my wife Rania and my children Marilena and Vasilis,
whose love and support made this book a reality

PVG

To Claudia and Julia, who missed me while I was on call

HCP

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Preface

Over the years the evolution of orthopaedic surgical techniques led to the development of a plethora of orthopaedic textbooks aiming to present the principles of modern orthopaedic surgical practice in order to contribute to the continuing medical education of all the orthopaedic surgeons in training.

The notion of this book arose during the first years of our training. It was difficult to find a book to refer to as a quick yet thorough reference, prior to performing a surgical procedure.

Our aim was therefore to develop a book that would contain a step-wise approach to performing a surgical procedure. Details have been included such as positioning of the patient, the approach and reduction technique, the implant to be inserted, the protocol of post-operative mobilization, complications to look for, when the patient should be seen in the outpatient clinic and whether the implant should be removed. Intraoperative pictures have been incorporated to allow the surgeon to be aware of all the important issues involved.

The most common trauma procedures that a surgeon in training is expected to perform during his residency have been included. Each procedure has been written by an expert or under the supervision of an expert.

This book is expected to be the companion for the resident in training during the long on-call nights in the hospital while preparing for the operations necessary to help our trauma patients.

Acknowledgments

During the preparation of this book we had the pleasure of working together with people whose efforts and contribution made possible the birth of this edition. We particularly wish to acknowledge Cambridge University Press, and our publishing directors Geoffrey Nuttall and Peter Silver for their commitment to this project and the maintenance of this level of excellence.

Without the dedication and the hard work of our hospital staffs we would not have been able to accomplish this project.

We would also like to thank all the contributors who have shared with us their expertise.

We also appreciate the continuing support of our colleagues at our university hospitals and especially the daily stimulus of our registrars, whose quest for knowledge remains the major motivation and encouragement for our efforts.

Part I

Upper extremity

1

Fractures of the clavicle

Peter V. Giannoudis

1.1 OPEN REDUCTION AND INTERNAL FIXATION (ORIF) OF MIDSHAFT FRACTURES

Indications

(a) Open fractures.
(b) Painful non-union.
(c) Associated injury to the brachial plexus and/or subclavian artery.
(d) Floating shoulder.
(e) Bilateral fractures.
(f) Multiple-injured patient.
(g) Soft tissue interposition between the fragments.
(h) Impending skin necrosis or penetration from a prominent fragment.

Pre-operative planning

Clinical assessment

- Mechanism of injury: motor vehicle accident, sports injury, fall on outstretched hand, direct trauma.
- Deformity, ecchymosis, swelling, tenderness, crepitation.
- Look for pneumothorax or haemothorax, especially in presence of associated injuries.
- Assess and document vascular status of the upper arm and any difference in peripheral pulses between the injured and contralateral extremity.
- Assess neurological status (usually brachial plexus injury presents as an upper roots traction injury).

Radiological assessment

- Anteroposterior view of the clavicle, including sternoclavicular and acromioclavicular joints (Fig. 1.1).
- Oblique views.
- Lordotic view (usually after surgery for ORIF evaluation).

Operative treatment

Anaesthesia

- General anaesthesia at induction.
- Administration of prophylactic antibiotics as per local hospital protocol (usually second generation of cephalosporin is administered).

Table and equipment

- AO small fragment (3.5 mm) set.
- Ensure availability of the pre-planned plate length. A 3.5 DCP plate or a reconstruction plate can be used (Fig. 1.2a,b).
- Standard osteosynthesis set as per local hospital protocol.

Table set up

- The instrumentation is set up on the side of the operation.
- Image intensifier is from the ipsilateral side.
- Position the table diagonally across the operating room so that the operating area lies in the clean air field.

Practical Procedures in Orthopaedic Trauma Surgery: A Trainee's Companion, ed. Peter V. Giannoudis and Hans-Christoph Pape. Published by Cambridge University Press.

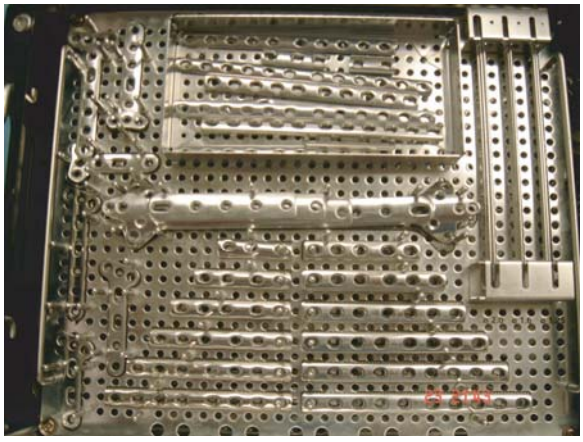
Fig. 1.1 Anteroposterior view of the clavicle, including sternoclavicular and acromioclavicular joints.

Draping and surgical approach

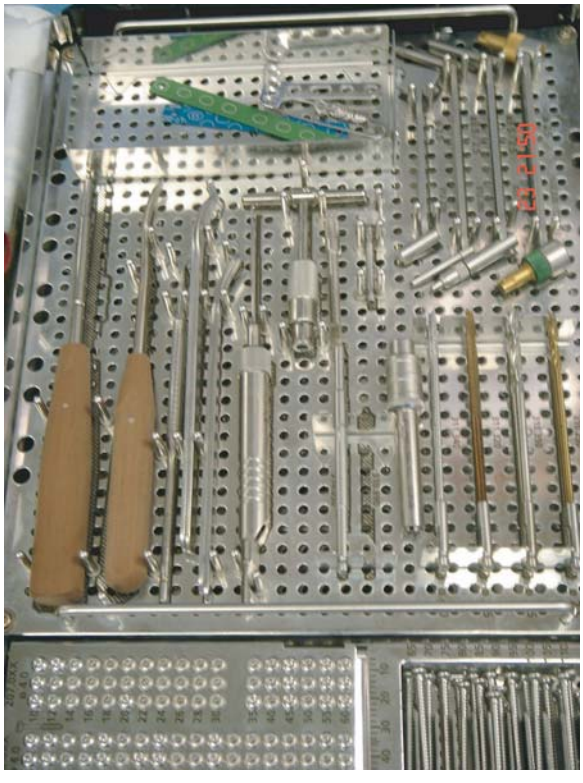
- Skin preparation is carried out using usual antiseptic solutions (aqueous/alcoholic povidone-iodine).
- Prepare the skin of the chest to the medial border of the scapula. Clean up to the anterior and lateral surface of the neck and down to below the level of the nipple.
- Use single U-drapes (Fig. 1.3 a,b).
- Make an incision over the clavicle (Fig. 1.4 a,b).
- Using the cutting diathermy bring down the incision through the skin to the periosteum (Fig. 1.5).
- Identify the clavicle and the fracture fragments.
- Perform a subperiosteal dissection on the clavicular edge and circumferentially only at the fracture site (Fig. 1.6).
- Drill a hole to the bone through a plate hole above the distal fragment and affix the plate to the distal fragment (Fig. 1.7).
- Then reduce the proximal fragment and secure the plate positioning over the bone by using a clamp.
- Place one screw at the proximal fragment and ensure reduction maintenance with fluoroscopic control (Fig. 1.8).
- Place the rest of the screws in the same manner (Fig. 1.9).
- Cancellous bone grafting is performed for bone defects or devitalized bone.
- Ensure fracture reduction, adequate screw length with fluoroscopic Lordotic views.

Closure

- Closure is performed as a full-thickness layer over the plate using 2/0 Vicryl and 3/0 subcuticular sutures for the skin (Fig. 1.10 a,b).



(a)



(b)

Fig. 1.2 a,b A 3.5 DCP plate or a reconstruction plate can be used.

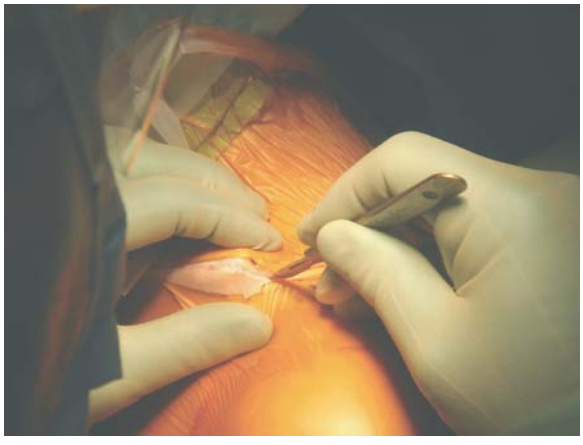
Post-operative treatment

- Assess and document the neurovascular status of the extremity.
- Obtain post-operative radiographs (Fig. 1.11).
- Use a sling for the initial 10 post-operative days (Fig. 1.12).

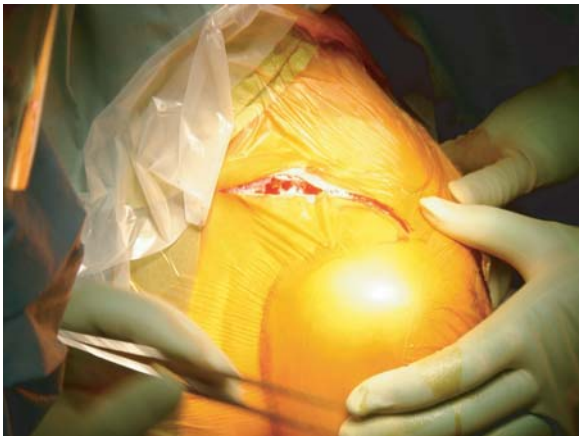
(a)

(b)

Fig. 1.3 a,b Positioning and draping of the patient.



(a)



(b)

Fig. 1.4 a,b Make an incision over the clavicle.

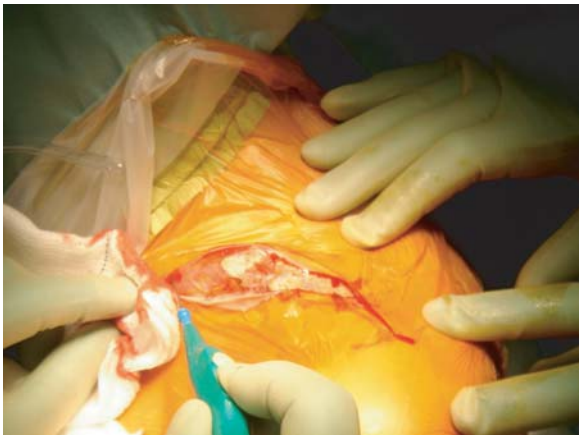


Fig. 1.5 Using the cutting diathermy bring down the incision through the skin to the periosteum.

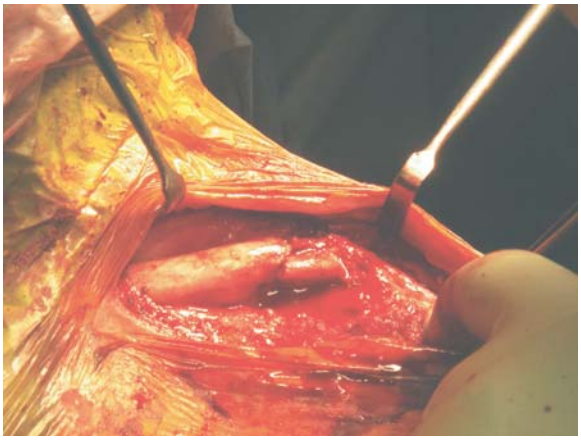


Fig. 1.6 Perform a subperiosteal dissection on the clavicular edge and circumferentially only at the fracture site.

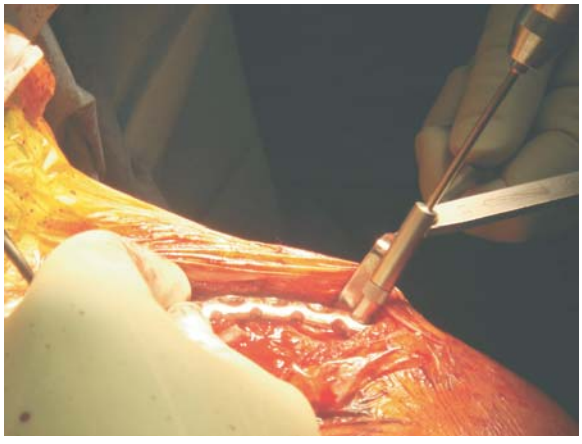


Fig. 1.7 Drill a hole to the bone through a plate hole above the distal fragment and affix the plate to the distal fragment.

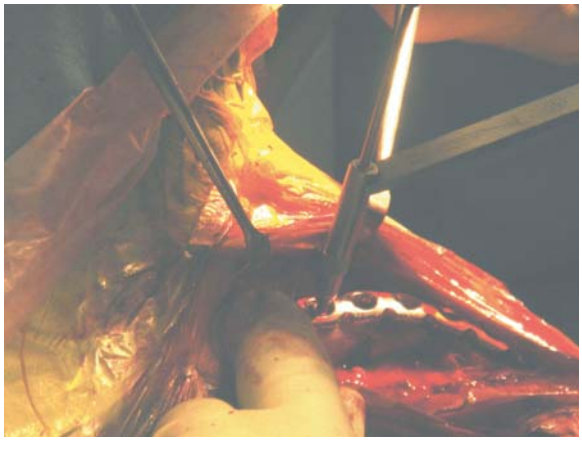


Fig. 1.8 Place one screw at the proximal fragment and ensure reduction maintenance with fluoroscopic control.

Fig. 1.9 Place the rest of the screws in the same manner.

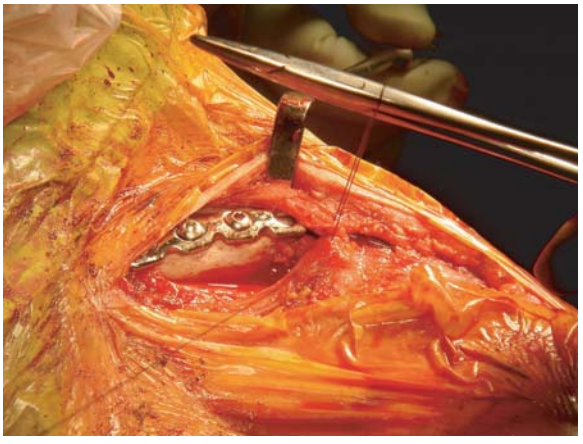


Fig. 1.10 (a)

Fig. 1.10 (b)

Fig. 1.10 a,b Closure is performed as a full-thickness layer over the plate using 2/0 Vicryl and 3/0 subcuticular sutures for the skin

Fig. 1.11 Post-operative radiograph.

Fig. 1.12 Use a sling for the initial 10 post-operative days.

- Initiate active flexion and abduction 6 weeks after injury.
- Return to prior activities is possible 3 months after operative treatment.

Outpatient follow up

- Review at clinic in 3, 6 and 12 months with X-rays on arrival to consider plate removal.
- Beware of late vascular complications (thrombosis, pseudoaneurysm).

Implant removal

- Plate can be removed after 12 months.

2

Section I: Fractures of the proximal humerus

David Limb

2.1 GENERAL CONSIDERATIONS

The practicalities of surgical management of proximal humeral fractures are common to the various injuries treated. A generic description of the investigations required and practical set-up of the operating room will therefore be presented before discussing specific injuries.

Radiological assessment

- It is essential that all shoulder fractures be assessed with a minimum of two shoulder views – the antero-posterior (AP) and axial views.
- A scapular lateral completes the trauma series but is not always essential.
- The axial view can be obtained successfully in most cases – in the rare instances where the patient will not permit sufficient movement of the injured limb away from the side, angled views (modified axial) should be obtained. Never miss a dislocation (too many are missed, and most of these have not had an axial view taken).
- In complex cases a CT scan might assist, particularly in assessing whether the humeral head is intact and has any tuberosity attachments remaining. A humeral head fragment with an attached tuberosity is much less likely to suffer avascular necrosis than one with no remaining tuberosity attachments. Three-dimensional CT is particularly useful for assessing glenoid fossa fractures.

Anaesthesia

- General anaesthesia or scalene blocks can be used. Even if general anaesthesia is selected, a scalene block can add useful analgesia.
- The risk of phrenic nerve palsy and pneumothorax should be considered if a scalene block is to be used, particularly if there is already chest trauma (which not infrequently accompanies shoulder trauma).
- Great care has to be taken to avoid interference with anaesthetic tubes and pipes by the surgeon or assistant in general anaesthetic cases.

Table and positioning

- The table should allow the patient to be sat up at the hips into the beach chair position (Fig. 2.1). Usually the torso is raised 30 to 45° from the horizontal, but if access is needed to the front and back of the shoulder then a more upright position is necessary, supporting the spine and head but allowing access to the whole shoulder girdle.
- To avoid the patient sliding down the table, the table is tilted 'feet up' below the hips. The knees are flexed by lowering the end of the table or by placing a pillow behind the knees.
- Any part of the table that could intervene between the ends of a C-arm during X-ray screening of the shoulder should be radiolucent.
- Shoulder table attachments are available that convert normal operating tables to permit patient positioning as described above (e.g. Schlein table attachment).

Operating room set up

- Shoulder surgery requires the surgeon to stand in the axilla of the patient on the side of the injury. Either the C-arm is positioned, or an assistant stands, above the patient's shoulder.

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Fig. 2.1 The beach chair position.

Fig. 2.2 C-arm draping and positioning for X-ray control during surgical fixation of shoulder fractures.

- The hand and forearm are draped and rested on a small table. The height of the table should be adjustable.
- It is preferable for the head of the table to be furthest away from the anaesthetic machine. The anaesthetist should be aware of this, as extension tubes may be needed for the gas lines.
- Alternatively the anaesthetist can work from the side of the patient opposite to the operated shoulder, with a suitable exclusion drape.
- An experienced radiographer is required to obtain good X-ray views of the shoulder during surgery.
- If the anaesthetist is working at the foot end of the patient, the scrub nurse can work across the patient's chest, provided great care is taken with anaesthetic pipes beneath the drapes. Alternatively the nurse can stand adjacent to the small table upon which the patient's arm rests.
- If no X-ray screening is necessary the scrub nurse can work from above the head end of the table or on the same side as the surgeon. If X-ray screening is used, the nurse works across the chest (see above) or from the same side as the surgeon.

Draping and approach

- Skin preparation is carried out using locally approved antiseptics. Prepare the forequarter from the midline of the chest to the medial border of the scapula. Clean up to the root of the neck and down to below the level of the nipple. The arm is prepared down to wrist level.
- A U-drape is used to shut off the forequarter and a separate impervious stocking is rolled up the arm to above the level of the elbow. This leaves the draped arm free for manipulation during surgery. It is rested on the arm table and raising this relaxes the deltoid by abduction of the arm. This facilitates exposure of the humeral head.
- A deltopectoral approach is preferred for management of all proximal humerus fractures. It is possible to reduce and stabilize a greater tuberosity fracture through a deltoid split. If unexpected comminution is discovered or later surgery is required for complications, a deltoid split cannot be safely extended without risking injury to the axillary nerve.
- If X-ray screening is to be used, both ends of the image intensifier C-arm are covered with sterile drapes. The intensifier is positioned above the affected shoulder and angled in towards the midline by 20–30°. This will correct for the angulation of the scapula on the chest wall and give good views of the joint line.
- The C-arm passes over the shoulder, with the source anterior and the collimator behind the shoulder (Fig. 2.2). This gives good AP views during surgery and permits the C-arm to be rolled into a vertical position for axial views.

Surgical approach

- The incision for a deltopectoral approach extends from the clavicle across the lateral edge of the palpated coracoid process and down to the arm into the interval palpable between the anterior edge of the deltoid muscle

Fig. 2.3 The deltopectoral incision.

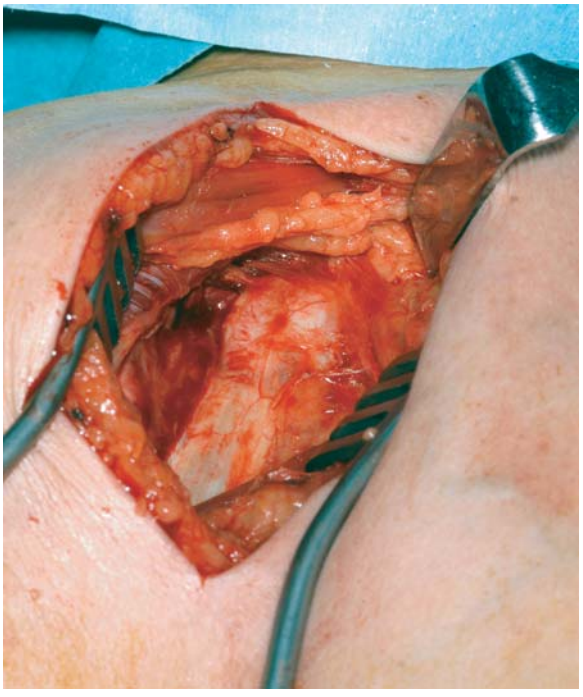


Fig. 2.4 Retraction to expose the subscapularis and proximal humerus.

and the adjacent biceps muscle (Fig. 2.3). The length of the incision is determined by the extent of exposure required.

- The deltoid and pectoralis major are separated digitally, retracting the cephalic vein (which marks the interval) laterally – cutting muscle fibres is not necessary. The interval can often be located by a fat stripe if the cephalic vein is not immediately apparent.
- Once fascia is exposed deep in the deltopectoral interval it is opened vertically, adjacent to the lateral border of the conjoint tendon as far up as the tip of the coracoid process.
- Sweep a finger under the conjoint tendon to ensure the axillary nerve is not in close proximity. Sweep a finger under the deltoid to ensure the subdeltoid bursa is opened – these two spaces are placements for the two blades of a self-retaining retractor (Fig. 2.4).
- The proximal humerus is now as visible as it is ever is – clothed in the thick rotator cuff tendons. The long head of biceps tendon can be identified at the lower part of the incision and followed in to the interval between subscapularis medially and the greater tuberosity with supraspinatus attachment laterally and above.

2.2 TENSION BAND WIRING (TBW) FOR DISPLACED GREATER TUBEROSITY FRACTURES

Indications

Fractures of the greater tuberosity displaced by 5 mm or more.

Note

- Many consider this recommendation, commonly quoted in the literature, to be excessively conservative and would offer surgery for fractures displaced by as little as 2 mm.
- Displacement cannot always be judged on an anteroposterior (AP) film, as the infraspinatus and teres muscles will displace the tuberosity posteriorly and medially behind the humeral head. It is essential that at least an axial view of the shoulder is also taken to properly assess displacement.

Pre-operative planning

Clinical assessment

- Shoulder pain is often felt in the region of the deltoid insertion, on the lateral aspect of the arm.
- Look for any history suggestive of dislocation – greater tuberosity fractures are not uncommonly associated with anterior shoulder dislocation. Often repair of the tuberosity fracture (if displaced after reduction) will stabilise the shoulder, but be aware that soft tissue procedures such as labral repair could be necessary either at the time of tuberosity repair, or later.
- Assess and document the neurovascular status of the arm. It is particularly important to examine the axillary nerve. Since deltoid function can be severely compromised by pain, skin sensation in the 'regimental badge' area should be carefully recorded.

Radiological assessment

- Anteroposterior (Fig. 2.5) and axillary views are essential. A scapular lateral view completes the trauma series, though is not essential in the assessment of isolated greater tuberosity fractures.
- Pre-operative X-ray screening should be available, particularly in multifragmentary greater tuberosity fractures. The fragments can be impossible to see at surgery, being hidden from view by the thick rotator cuff tendons.

Fig. 2.5 Displacement of the greater tuberosity into the subacromial space.

Operative treatment

Anaesthesia

- General anaesthesia with prophylactic antibiotics according to local protocols.
- Scalene block according to anaesthetic skills available.

Table and equipment

- The table must allow the patient to be sat up in the 'beach chair' position and allow access to the shoulder by a C-arm.
- A table attachment allowing the same position, supporting the torso and head, is equally acceptable (e. g. Schlein table attachment).
- A small Mayo table, suitably padded and covered, can be used to support the arm.
- Drill with 2–2.5 mm bit.
- Heavy non-absorbable suture material (e. g. No. 5 Ethibond®) – stainless steel wire can be used, but because it is used around a tendon insertion it will fragment and migrate once shoulder function is restored.

Table set up and patient positioning

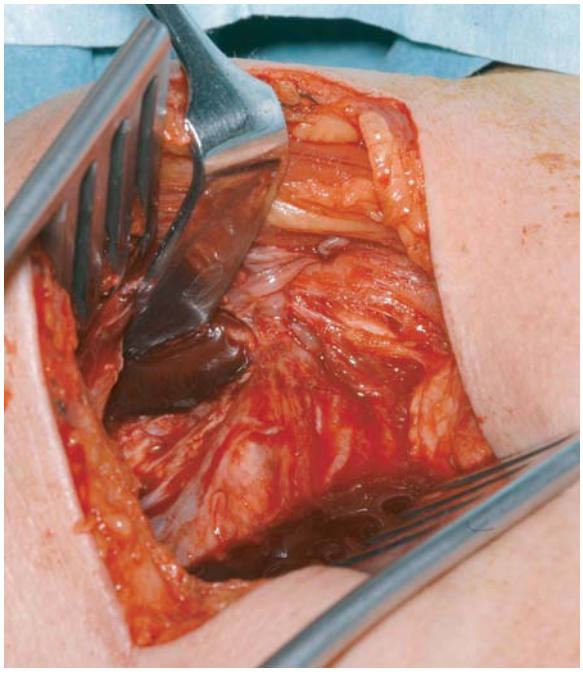
- The patient is sat up approximately 45° (beach chair position).
- Arrange the table in theatre so that the surgical team have access to the head and affected side of the body.
- The affected arm is draped free and rested on a padded Mayo table. The height of the table is adjusted to hold the arm in 30–45° of abduction, thus relaxing the deltoid muscle and facilitating access to the proximal humerus.
- Image intensifier access is in line with the body, from the head end of the table. Both ends of the C-arm are covered in sterile drapes.

Draping and surgical approach

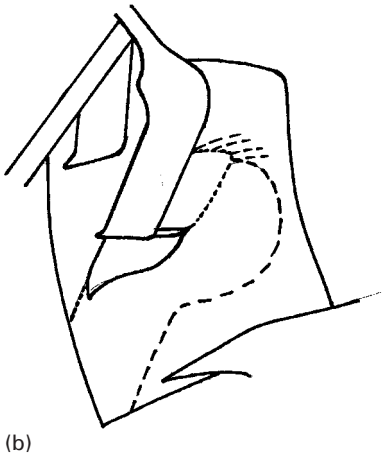
- Skin preparation is carried out as described above.
- A deltopectoral approach is preferred for the management of all proximal humerus fractures, as it can readily be used for any later procedures that become necessary. It is possible to reduce and stabilise a greater tuberosity fracture through a deltoid split.

Surgical fixation

- The deltopectoral approach or deltoid split takes the surgeon down to the bed of the greater tuberosity – exposed cancellous bone is found (Fig. 2.6 a,b), but the tuberosity itself often has to be sought.
- The direction of displacement should be apparent on pre-operative X rays and anticipated in planning. It depends upon the fracture configuration and what are the dominant tendon attachments on the displaced fragments.
- If the fragment contains principally the supraspinatus tendon insertion then the tuberosity will displace into the subacromial space. Retrieval from here is usually easy, by grasping with tissue forceps.
- If the fragment includes principally the attachments on infraspinatus and teres (and this might be because of a chronic supraspinatus tear) then the fragment will displace behind the humeral head and can be more difficult to identify and retrieve.
- If the fragment is not easily palpable and cannot be grasped, it is still usually possible to identify the posterior rotator cuff by pulling the humeral head downwards. Place a heavy suture in the visible edge of the rotator cuff and pull – if the first tug does not deliver the tuberosity it can be retrieved by placing a further traction suture in the cuff tendon brought into view by the first traction suture.
- Once the tuberosity is identified assess the quality of the bone of the tuberosity and the head.
- If the tuberosity is a large single fragment with good bone quality then fixation can be obtained by lag screw fixation. If not, then a tension band technique is more appropriate.
- The material usually selected for tension band fixation is a No. 5 non-absorbable suture such as Ethibond. It is unlikely that the bone quality will be good enough for this to be placed through drill holes in the tuberosity for fixation – the best grip on the tuberosity is achieved by placing the suture to take a broad bite of the insertion of the rotator cuff onto the tuberosity fragment. For large fragments two sutures can be placed side-by-side in the cuff.
- The tuberosity fragment can be pulled into a reduced position using these sutures (Fig. 2.7 a,b) – the direction in which traction is exerted to bring about anatomical reduction (checked on a C-arm if necessary) determines where the suture material should be fixed to the proximal humerus. The tension suture can be fixed to a screw and washer or through drill holes in bone. The latter avoids any concern about later implant removal.

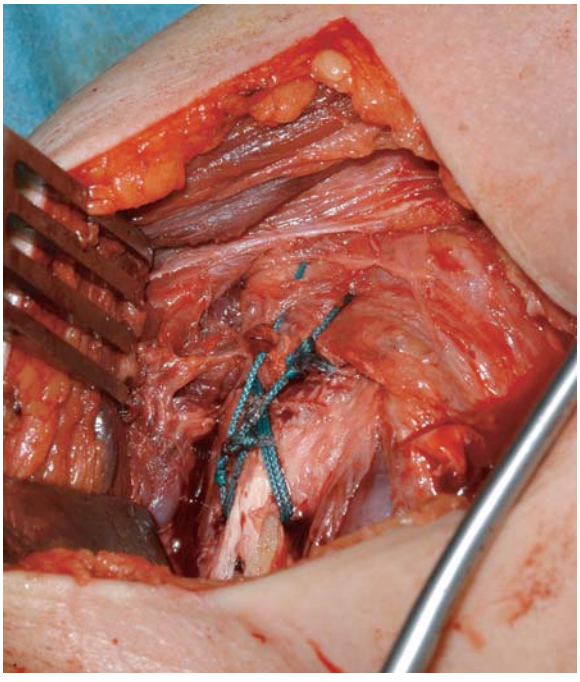


(a)

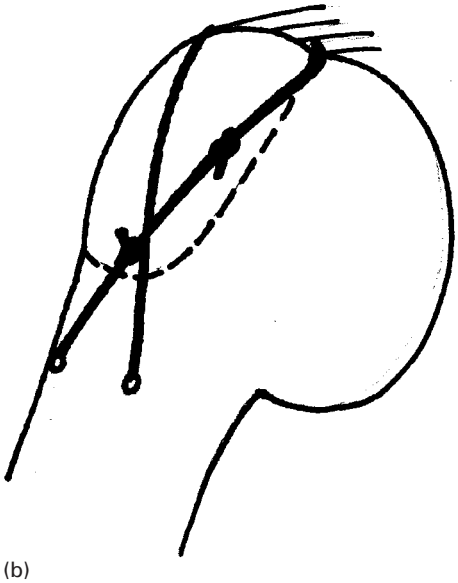


(b)

Fig. 2.6 a,b The bed of the greater tuberosity.



(a)



(b)

Fig. 2.7 a,b The greater tuberosity held in its bed by heavy tension band sutures.

- For posterior tuberosity fragments that displace in a posterior direction, it is often the case that traction has to be applied in an anterior direction to reduce the tuberosity. If this is the case, then a bite of the subscapularis insertion on the lesser tuberosity holds the tuberosity that was reduced by the tension band principle.
- For fragments that displaced in a superior or posteriosuperior direction it is observed that the reduction is held by pulling the Ethibond sutures down onto the lateral or anterolateral humeral shaft. Two drill holes are created using a 2.5 mm drill through which the needle is passed to create a tension band holding the tuberosity in a reduced position.
- Often the tuberosity is very fragmented – remember the important role of surgery is not to anatomically replace every small bony fragment, but to secure the rotator cuff back onto the proximal humerus and allow it to function. The reduction of bony fragments is checked and a search is made for any substantial fragments that remain displaced and might have a significant rotator cuff attachment. Occasionally fragments also have to be pursued if they are displaced into the subacromial space and might cause impingement.
- After fixation the field is washed out. It is not necessary to suture the deltopectoral interval, which falls back together. Drains are not usually necessary. Routine fat and skin closure follows and the patient is fitted with a collar and cuff sling.

Post-operative treatment

- Post-operative X rays confirm that a satisfactory reduction has been achieved (Fig. 2.8).
- The point of fixation is to allow early mobilization. Passive physiotherapy can commence immediately.
- The duration of sling use, return to active use and resistive exercises depend to an extent on operative findings. If the tuberosity was a substantial fragment and has been replaced in its bed, then fixation is usually secure enough to allow the sling to be discarded as soon as initial pain settles. Active use for activities of daily living can also begin immediately, though resistive exercises and lifting should be deferred until time has been allowed for bony union – often an empirical 6 weeks.
- If the tuberosity fragments were small and the repair were more akin to repair of the rotator cuff edge into the bony bed, then a more cautious approach to mobilization is indicated.
- In the latter case it is reasonable to allow immediate passive and active-assisted physiotherapy but also to continue with arm support for 6 weeks or so. Work against resistance is introduced cautiously at 6 weeks and built up over the next 6 weeks. Heavy lifting might

Fig. 2.8 Post-operative films demonstrating adequate reduction of the greater tuberosity.

be deferred by 3 months and in extreme cases, where a poor quality cuff was found and repaired into the tuberosity bed, then this might even be delayed until 6 months.

2.3 OPEN REDUCTION AND INTERNAL FIXATION (ORIF) OF 3- AND 4-PART FRACTURES (USING A PHILOS PLATE®)

The decision to treat a 3- or 4-part fracture by internal fixation or by prosthetic hemiarthroplasty can be very difficult. Patients fare much better if they can keep their own humeral head, restored to a reasonable anatomical configuration with an effective rotator cuff.

The best functioning joint replacements however are those that are carried out as a primary procedure – the results are far poorer if hemiarthroplasty is carried out because of failed fixation or for complications of the fracture and its treatment. Sadly we cannot often predict which of our patients will be unlucky enough to follow a complicated course.

This section assumes that a decision has been made to treat a fracture surgically. The range of surgical options is wide. The underlying principle, as with any periarticular fracture, is that the joint surface is reconstructed to articulate anatomically with the glenoid and is then secured with the correct length, alignment and rotation onto the shaft. A prerequisite of regaining a near-anatomical articulation, however, is that the tuberosities have to be restored to their correct locations in order for proper articulation to occur. The surgical option described here uses a specially designed plate to fulfil these criteria, though the principles described can be applied using alternative devices.

Anaesthesia, table and patient positioning and the surgical approach (deltopectoral) have already been described. The principles of tuberosity fixation described above will also be followed.

Equipment

- General set for the surgical approach, including adequate retractors. A Norfolk and Norwich self-retaining retractor is usually sufficient but specially designed shoulder retractors improve exposure. Unfortunately they also interfere with radiological screening and are more difficult to remove and replace when checking progress on X ray.
- Philos plate set – plates of different lengths are available and the set includes a jig for correct aiming of locking screws.
- Small fragment set including locking screws.
- No. 5 ethibond (or similar) sutures.

Surgical approach

- As already noted, the deltopectoral approach is used to expose the proximal humerus. This should be extended far enough down the arm so that the tendon insertions of the pectoralis major muscle and deltoid can be located. This determines where the plate will lie on the shaft – sufficient anterior deltoid is elevated only to allow the plate to sit down to touch bone – do not detach either tendon.
- At this point the fracture is almost invisible! If only we could see all the fragments that are visible on X rays

Fig. 2.9 Displaced proximal humerus fracture to be treated by plate fixation.

(Fig. 2.9), these fractures would be so much easier to fix.

- It is important that the reduction process does not further compromise the blood supply to the humeral head. Detachment of cuff tendons and capsule is *not permitted* – X rays are essential to check reduction.
- Any fracture line splitting the tuberosities is identified. Heavy No. 5 Ethibond sutures are placed in the insertion of the subscapularis onto the lesser tuberosity and supraspinatus/infraspinatus on the greater tuberosity. If necessary traction can be applied to these to pull the tuberosities back to their expected positions – don't worry if the humeral head still appears displaced on X ray.
- An instrument such as a small fragment periosteal elevator is inserted through the fracture line and is used to push the humeral head up into the coracoacromial arch.
- As the humeral head is restored towards its anatomic location the tuberosities fall, or can be pulled, back into their beds around the head fragment. By temporarily clipping the Ethibond sutures together, holding the tuberosities beneath the humeral head, the reduction of the head and tuberosities can be gauged with the arm held in neutral rotation.

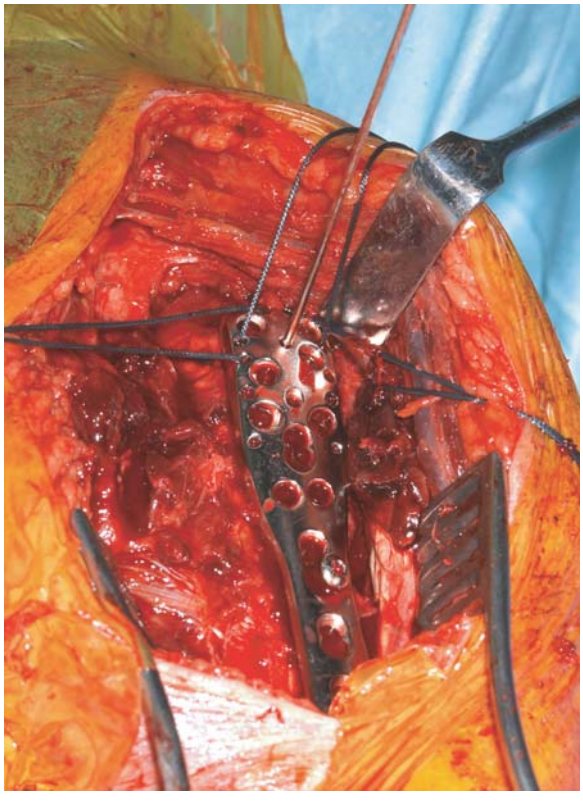


Fig. 2.10 Sutures placed in the cuff insertions onto tuberosities are passed through holes in the plate for secure tuberosity fixation.

- Once a satisfactory reduction has been achieved it is held using the tension band sutures. Since the shaft is fractured, however, the tension sutures can be passed through appropriately positioned holes on the Philos plate (Fig. 2.10). It is very difficult to pass heavy sutures through these holes once the plate has been fixed to bone. The plate is slid down the sutures, pressed against the reconstructed head and the tension sutures can be tied after checking plate height (Fig. 2.11).
- The plate height on the humerus is such that it should reach almost to the cuff insertion on the greater tuberosity. Any higher and it can cause impingement afterwards. If there is a tendency for the plate to be pulled out of position as the tension sutures are tied through the plate its position can be fixed by a temporary K-wire through one of the small holes in the plate.
- The plate is then attached to the shaft of the humerus. A slotted hole allows some adjustment of the plate height

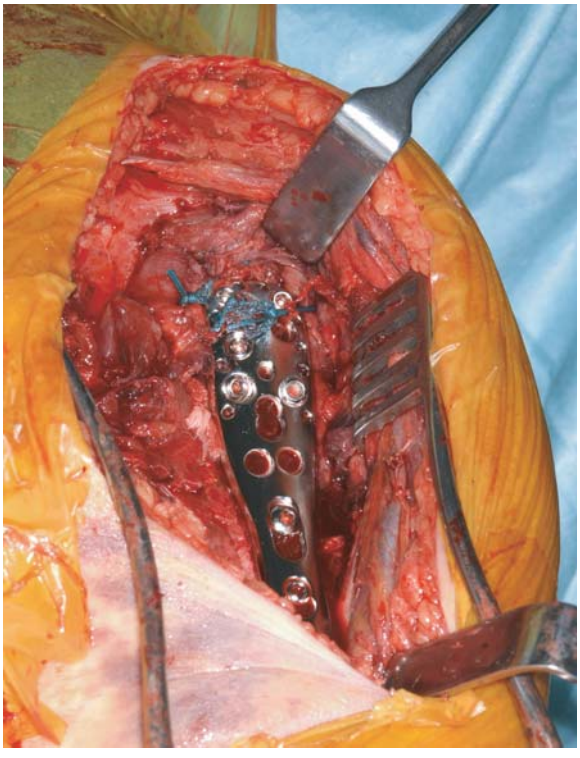


Fig. 2.11 Preplaced sutures are tied for secure fixation of tuberosity fragments that may not be captured by screws.

Fig. 2.12 The Philos plate®. Note the broad, low-profile upper segment for locking screws into the head and a lower plate for fixation to the shaft. The uppermost hole of the shaft segment is a slot to allow fine tuning of plate height so that it does not project above the tuberosity and impinge.

or shaft impaction into the head after the screw hole is drilled (Fig. 2.12).
- Once the plate is in a satisfactory position and the tuberosities are controlled by tension sutures, the whole proximal humerus can be stabilized in this position by the placement of locking screws through the plate into the head and tuberosities.
- Check films in both AP and axial planes are obtained from the image intensifier.
- Routine closure of fat and skin layers after a washout.
- Temporary shoulder immobilizer until post-operative pain has settled.

Post-operative care

- The aim of fixation is to allow early mobilization.
- Check X rays in AP and axial planes (Fig. 2.13).
- Immediate passive and active assisted mobilization – care has to be taken in passive stretching of internal and external rotation for the first 6 weeks, as some tuberosity fragments might be held only by tension band sutures.
- Implant removal is not usually necessary.

Complications

- Fixed angle devices such as this give an excellent hold even in osteoporotic bone. The fact that the implant is a fixed device also causes problems if avascular necrosis develops.
- Avascular necrosis results in collapse of the humeral head. The implant remains fixed, however, and the screws do not back out as they do with T-plates. Consequently the screws can perforate the humeral head. This should be anticipated and if necessary appropriate action taken by either removing the screws or revising the implant to a hemiarthroplasty.

Fig. 2.13 Postoperative film demonstrating adequate reduction of the fracture.

2.4 HEMIARTHROPLASTY FOR FRACTURE DISLOCATION

Indications

- Debatable!
- Fracture dislocations in which the humeral articular surface has no remaining soft tissue attachments, which have a very high incidence of avascular necrosis.
- Head splitting fractures, which have a high incidence of necrosis of at least one of the head fragments or involve comminution of the head and crushing of articular cartilage with inevitable post-traumatic arthritis
- Chronic fracture dislocations (usually posterior) with destruction of 50% or more of the humeral head (Figs. 2.14 a,b).
- Severe 3- or 4-part fractures in which it is assessed, and agreed with the patient, that immediate hemiarthroplasty is likely to give a better outcome on balance than fixation with the attendant risks (Fig. 2.15). This requires an assessment of the personality of the fracture and an appraisal of how well reconstruction could restore normal mechanics, the risks of re-displacement or avascular necrosis (AVN) and the various patient-dependent factors that affect rehabilitation and outcome.

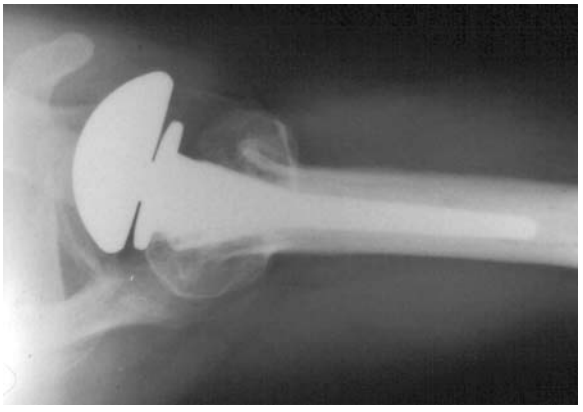
Patient positioning

- The beach chair position is used, though the torso is only angled upright by 30–45° – this allows the humerus to be dropped into a vertical position and from there allows slight adduction of the humerus behind the patient to improve access to the shaft.
- The side table is used at a low height in order that the arm can be dropped to a vertical and extended position, allowing access to the humeral shaft for preparation and prosthesis insertion.

Equipment

- Dedicated instruments are necessary for shoulder hemiarthroplasty. These have become more sophisticated as jigs have been developed to allow implant placement at a preselected depth within the humeral shaft and with correct rotational alignment within the shaft.
- Dedicated fracture implants are also emerging on the market. Whilst Neer's original prosthesis gave few choices of head or stem size, current modular systems allow a wide variety of stem sizes and head configurations (depth, radius of curvature, offset, head-stem angle). Fracture-specific stems have more space for bone graft and tuberosity placement beneath the humeral head. It is vital therefore that the surgeon checks that a full set of instruments and a full inventory of fracture implants is available.
- Fixation is obtained only through the distal stem in the shaft of the humerus. Although uncemented prostheses are available, which press-fit distally sufficiently well for use in trauma, most surgeons prefer to cement components to give the good initial rotational control of the stem in the shaft that is necessary for mobilization. Cement mixing chambers and a cement gun are therefore needed.
- The canal can be plugged with bone from the humeral head, but alternatively a cement restrictor might be used.

(a)



(b)

Fig. 2.14 (a) Axial view of a chronic locked posterior fracture dislocation; (b) axial view of same patient after prosthetic replacement, restoring stability.

Fig. 2.15 Fracture dislocation: for treatment by hemiarthroplasty.

Pre-operative planning

- Generally, X rays and CT scans have been used to determine if reconstruction is possible. These images can be used for planning purposes.
- The canal width is measured from X rays, allowing for radiological magnification or digital resizing. With conventional radiographs templates might be available from the manufacturer to estimate stem size (allow for a cement mantle by subtracting up to 2 mm from the measured minimum canal width).
- The humeral head diameter and depth can be measured to give an indication of where to start when doing a trial reduction. Measurements are often inaccurate, however, due to tilting of the displaced head fragment.
- If hemiarthroplasty is being carried out for chronic posterior fracture dislocation a brace will be necessary to maintain reduction after hemiarthroplsty. A suitable external rotation +/− abduction brace should be measured and tested before surgery.

Surgical technique

- The greater and lesser tuberosities are identified and a heavy No. 5 Ethibond suture is placed in the region of the rotator cuff insertion of each (Fig. 2.16). These sutures can be used to control the tuberosities and later can be used as tension band sutures for definitive tuberosity fixation.