CHAPTER

20

Fracture Humerus Interlocking Nail

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INTRODUCTION

Intramedullary nailing in femur and tibia is the accepted modality of the treatment due to its efficacy of treating lower extremity fractures has been documented in many studies. Intramedullary nailing offers the benefits of anatomic alignment, semirigid fixation with limited soft tissue dissection, and early rehabilitation of the injured limb. However, the indications for intramedullary nailing in humeral fractures should be viewed with caution. The anatomy and function of the humerus are quite different from those of the long bones of the lower extremity:

- The humerus is not a "weight-bearing" bone; therefore, rigid internal fixation is not needed to maintain limb function during fracture healing.
- Whereas the intramedullary canal widens in the metaphyseal area of the tibia and femur, the humeral canal narrows significantly, increasing the risk of distal fragment comminution **(Figs. 1 and 2)**.
- The anatomy of the upper arm also predisposes the patient to an increased risk of soft tissue injury, particularly the rotator cuff.
- The potential for neuromuscular injury is greater in humerus nailing than in the nailing of lower extremity fractures.
- The humerus bone on either side has highly mobile joints and also the entry to the humerus bone both by prograde and retrograde is eccentrically placed unless the entry is taken through the joint surface.

Before embarking on humerus nailing, one should understand the obstacles that can be encountered.

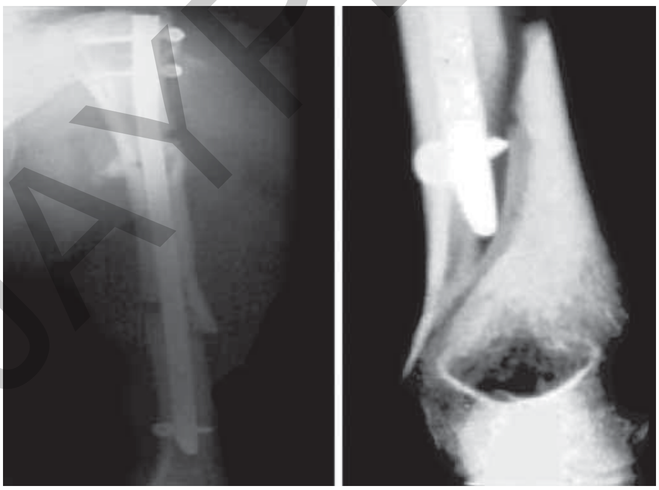


FIG. 1: If nail is too long, it can create fracture at lower end.

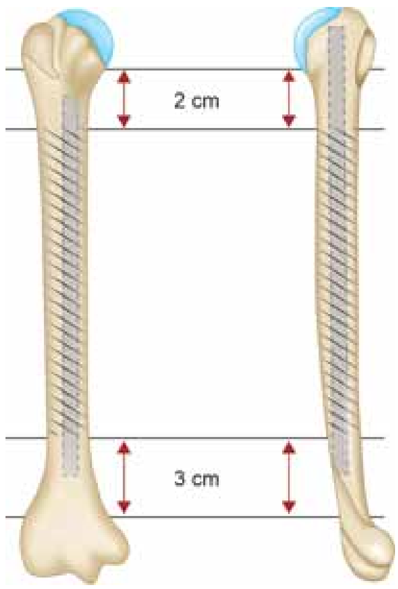


FIG. 2: Ideal zone for interlocking.

An adequate planning will minimize these difficulties. The rotator cuff injury, proximal humerus articular cartilage destruction, radial nerve injury, and extension of comminution are all possible complications of this procedure. Area of humerus shaft which can be nailed is limited by its anatomy **(Fig. 2)**.

PROCEDURES

Patient Positioning

The patient should be positioned on a radiolucent table that allows visualization of the whole upper extremity on the C-arm. The C-arm should be positioned on the side opposite to the fracture to prevent the C-arm bar from interfering with the maneuverings **(Fig. 3)** during the surgery and to allow easy handling of instrumentation. It is mandatory before starting the surgery to make sure that the rails and supports in the table do not block visualization of the whole length of the humerus **(Fig. 4)**.

Small angulation of the C-arm will be helpful, especially in beach chair position **(Fig. 5)**. In supine position, the C-arm is placed on the opposite as shown in **Figure 6**.

The patient should be positioned supine or in beach chair position **(Fig. 5)**, starting *from the head end* of table, so that surgeon can work from the head end during surgery. A roll is placed under the scapula, which extends the shoulder to expose the humeral head from under the acromion.

FIG. 3: Positioning of shoulder under C-arm.

FIG. 4: Patient position (supine).

FIG. 5: Beach chair position keep C-arm tilted like this.

FIG. 6: Keep C-arm on opposite side.

Incision Planning

Nowadays most surgeons including me use a percutaneous entry site with a small stab incision in line of deltoid fibers on the skin confirming the line of the medullary cavity on C-arm. Humeral head under anesthesia as well as due to extension by the roll placed under the scapula brings out the entry point of the shoulder in front of the acromion. Entry point more medial on the tuberosity may avoid injury to the cuff, also the incision in line with deltoid fibers will decrease the chances of inadvertent incising of the rotator cuff. Some nails have a small lateral bent proximally and they can be entered by a more lateral entry and they can avoid the injury to the rotator cuff to a great extent. But as the entry is very eccentric to the medullary canal, the chances of iatrogenic fracture of the medial wall are to be high and I have no personal experience with that entry. Theoretically injury to cuff is very minimal if at all by this entry site.

Conventional Nailing

When carrying out nailing of proximal humerus fractures, the proximal fragment is commonly in a marked abducted position due to contraction of the muscles. To judge entry site and plan rotator cuff incision, it is important to fully adduct the proximal humerus fracture. Proximal fragment adduction will assure adequate visualization of the rotator cuff before incision.

To decrease trauma to the rotator cuff, the optimal surgical incision site should be chosen. This may be difficult to palpate in case of a recent upper extremity fracture due to edema and hematoma. It is helpful to use a 1.5 or 2 mm K-wire to locate the anterior edge of the acromion as it intersects the longitudinal axis of the humeral canal. The first lateral skeletal projection that is palpated is usually the humeral head with the acromion being somewhat superior but more medial in direction. The image intensifier can help visualize the acromion and thus, differentiate it from the head of the humerus. Once the acromion edge is located, K-wire is inserted at the junction of articular and nonarticular part of the head as seen on C-arm image intensifier and its position and direction entering into the medullary canal is confirmed under C-arm both in anteroposterior (AP) as well as by internally or externally rotating the proximal fragment, then the incision is made in line with the deltoid fibers. A 1–1.5-cm incision over this K-wire is usually adequate to carry out nailing of the humerus percutaneously. An incision in line with the deltoid fibers taken or spreading of the muscle fibers with blunt dissection can be performed. But, if one wants to visualize the rotator cuff, a larger incision of 3 cm may be required. The skin and subcutaneous tissues are incised sharply. Elevation of the subcutaneous fat from the deltoid epimysium is helpful to expose the fascia plane between the anterior and middle third of the deltoid muscle fibers. An incision in line with the deltoid fibers or spreading of the muscle fibers with blunt dissection can be performed. The deltoid bursa is then encountered. Sharp dissection of the deltoid bursa from the rotator cuff is recommended to ensure visualization of the direction of the fibers of the supraspinatus tendon. Before incising, the rotator cuff, a K-wire should again be utilized to identify the optimal entry site.

To decrease rotator cuff trauma and postoperative complications, it is mandatory to make the incision of the rotator cuff sufficiently medial to its insertion site on the greater tuberosity. The rotator cuff does not have enough mobility near its insertion to allow adequate space for handling of the nailing instruments. By proper planning of the incision, the trauma to the rotator cuff can be minimized. The rotator cuff incision should be 1.5 cm in length and in line with the fibers. This incision should be approximately 1–1.5 cm medial to the greater tuberosity, depending on the exact anatomic relationship of the tuberosity and the lateral articular cartilage.

After completing the rotator cuff incision, it is advisable to take the stay sutures in the rotator cuff on both sides of the incision. It is helpful in many ways—first, it enables adequate retraction of the rotator cuff during the entire procedure. Secondly, it enables anatomical closure of rotator cuff.

Here are the steps of percutaneous antegrade humerus nailing as carried out routinely by the author.

Step 1 ***(Fig. 7)***: K-wire of 1.5 or 2 mm is passed just medial to the greater tuberosity on the junction of articular and

FIG. 7: Starting point of entry. Outer border of articular surface and medial to greater tuberosity.

nonarticular portion erring more on the articular side as that will be more in line with medullary canal. It is recommended that the C-arm image be utilized to confirm a good two-plane position of the K-wire in line with the intramedullary axis of the humerus. In most fractures, adequate external rotation of the proximal arm can be accomplished by manipulation to view both, a frontal and sagittal projection. If rotation is not adequately accomplished by the manipulation, a K-wire may be inserted from the lateral to medial direction to assist in manipulation of the proximal fragment. What is important is that the entry site K-wire should be in line with the medullary canal in two views at 90° to one another.

Step 2: Incision of 1.5 cm taken over the K-wire and by blunt dissection with a hemostat bone is reached **(Fig. 8)**. Care is taken to see that the incision is in line with deltoid muscle fibers and in turn in line with rotator cuff to avoid injury to rotator cuff **(Fig. 9)** and then with a hemostat is deepened up to the bone **(Fig. 10)**.

Step 3: The entry site is enlarged with a 4- or 5-mm cannulated drill bit which has inner diameter of 2 mm, so that long guidewire can be easily passed through this drill bit subsequently **(Figs. 11 and 12)**.

Step 4: After enlarging the entry site with cannulated drill bit over the K-wire, K-wire is withdrawn and a long guidewire of 2 mm is passed through the drill bit into the proximal fragment **(Fig. 13)**.

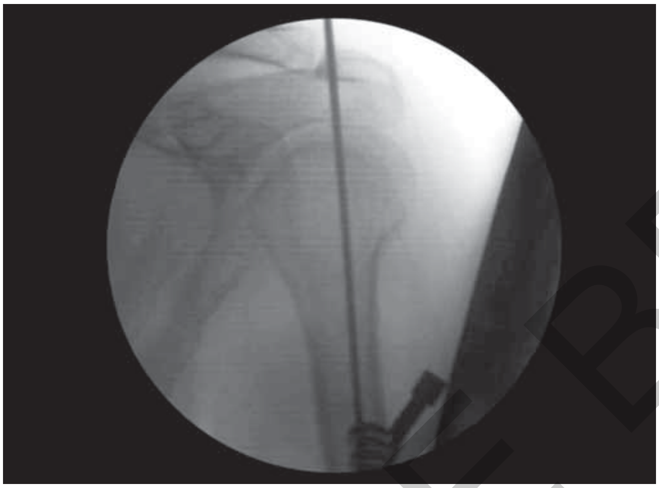


FIG. 8: Starting point of entry as seen in external rotation.

FIG. 9: Incision in line with deltoid fibers over the K-wire.

FIG. 10: Blunt dissection with hemostat.

FIG. 11: A 4-mm cannulated drill bit passed over K-wire.

Step 5: Assistant gives gentle traction holding the elbow flexed in 90°. As the shoulder is at a higher level, a towel underneath the distal fragment may align the fragment well **(Fig. 14)**. Reduction of humerus fractures usually proceeds smoothly with longitudinal traction provided by an assistant. Occasionally, direct manipulation is required to assist in the passage of the guidewire. The radial nerve is in close proximity to the intramedullary nail, which is susceptible for injury in closed nailing. Proximal fractures may be manipulated by accessory K-wires to properly position the fragments.

Step 6: Surgeon by using the cannulated drill bit as a joystick controls the proximal fragment and advances the guidewire across the fracture site into the distal fragment **(Fig. 15)**.

Step 7: The cannulated drill bit is withdrawn and the entry site enlarged with the entry site reamer of 8 mm which comes with the set or using a cannulated awl **(Fig. 16)**.

Step 8: Reaming is carried out sequentially from 6 mm onward till about 8.5 mm **(Figs. 17 to 19)**. As these reamers come with fixed reamer head, the reaming can be carried out over the simple guidewire itself. Reamer should be passed by pushing wherever it easily goes. Whenever resistance is felt, reaming should be done. While passing across fracture site, reamer should be gently pushed by hand and not while reaming with power to avoid any inadvertent entanglement of

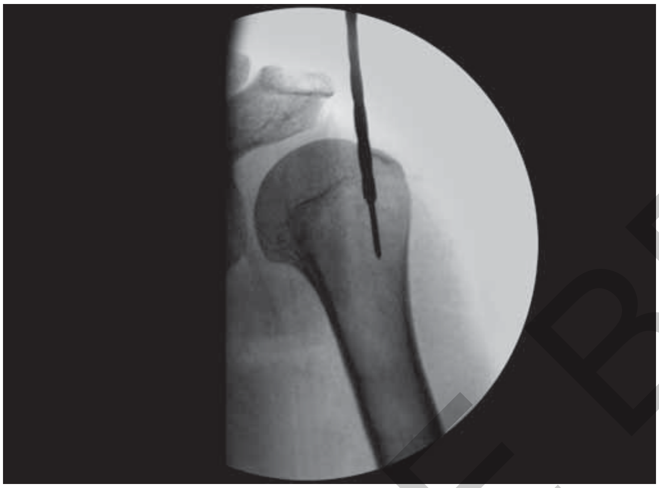


FIG. 12: Cannulated drill bit passed over K-wire.

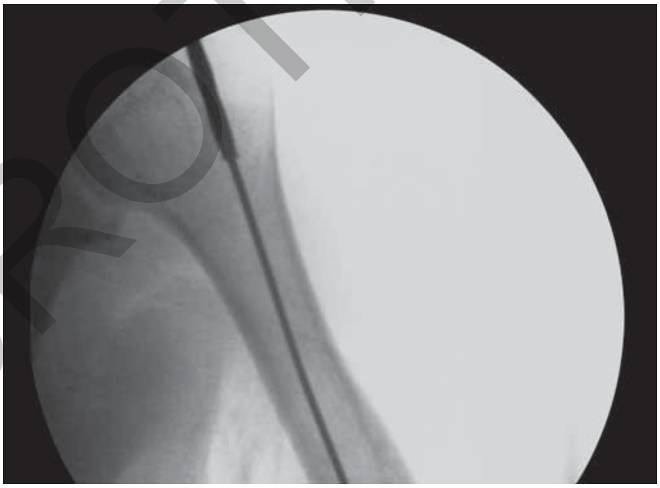


FIG. 13: A 2-mm long guidewire is passed through cannulated drill bit.

FIG. 14: Position of the assistant giving gentle traction. Note the towel under the distal fragment.

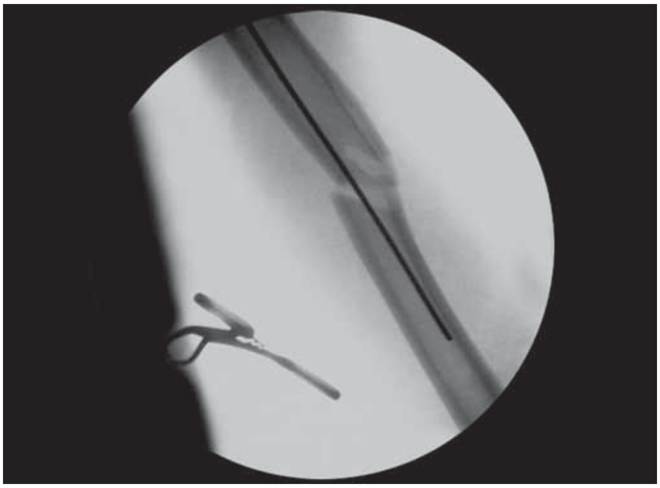


FIG. 15: A 2-mm long guidewire is passed and negotiated across fracture site.

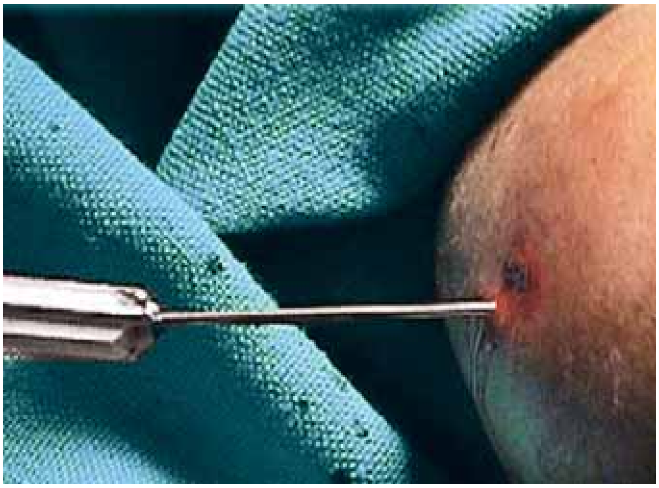


FIG. 16: Over the guidewire entry site enlarged with 8 mm reamer.

FIG. 17: 6–8.5 mm flexible reamer set.

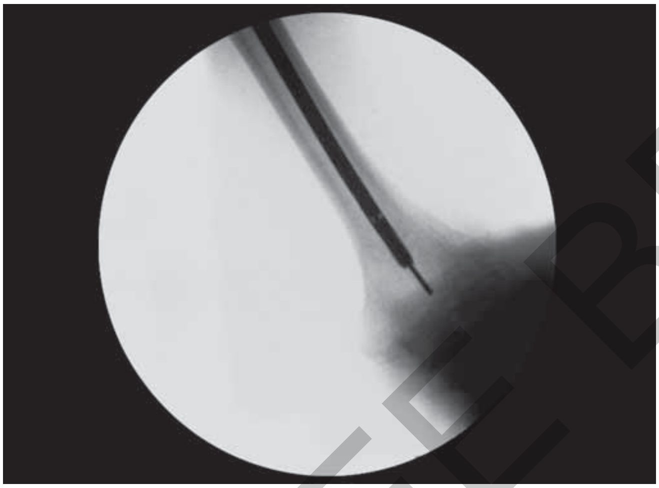


FIG. 18: Reaming with 6 mm reamer.

FIG. 19: Reaming with 8 mm reamer.

soft tissues at the fracture site. While reaming traction may not be required and the assistant should hold the reduction manually which is obtained while passing the initial reamers. In comminuted fractures, reamer is just pushed across the comminuted segment and this segment should not be reamed.

Step 9: Normally, the Indian medullary canal can be reamed up to 7.5 or 8.5 mm and a 7- or 8-mm cannulated humerus nail can be passed over the long guidewire **(Fig. 20)**. If the canal is too narrow then a solid nail of 6 mm may have to be used and passed by free hand technique **(Fig. 21)**. While passing the nail, it should be pushed by gentle rotational movements of the fore arm or by gentle blows over the head for insertion or insertion/extraction rod. Care should be taken to see that with each blow the nail advances further into the medullary canal. When the nail reaches the fracture site it should be passed across into the distal fragment only by gentle movements holding the jig. This will prevent inadvertent iatrogenic comminution at the fracture site. Once the nail is negotiated into the distal fragment, the nail is further advanced till the nail tip is about a centimeter from the olecranon fossa. Here too when the nail is being advanced into the distal fragment, a constant watch has to be kept over the fracture site to see if any undue distraction happens. Fracture site distraction can happen as the distal humeral canal is narrow, the nail is straight but the humerus is slightly bent anteriorly leading to the nail tip impinging against the posterior cortex of the distal humerus and the gentle pushing or hammering of the nail can cause distraction at the fracture site. Too much inadvertent distraction is known to cause radial nerve palsy and hence this care. The assistant should give counter support at the elbow holding

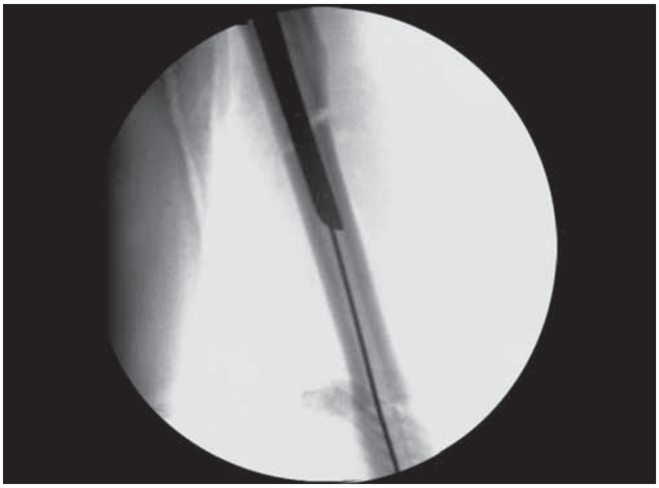


FIG. 20: Nail passing over guidewire.

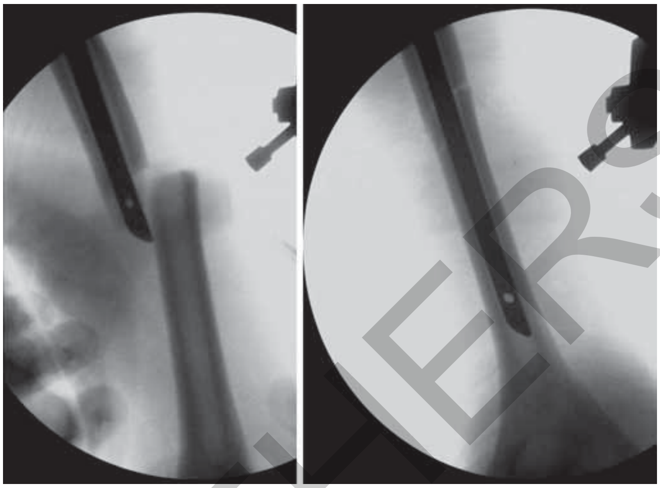


FIG. 21: Solid nail passing by free hand technique.

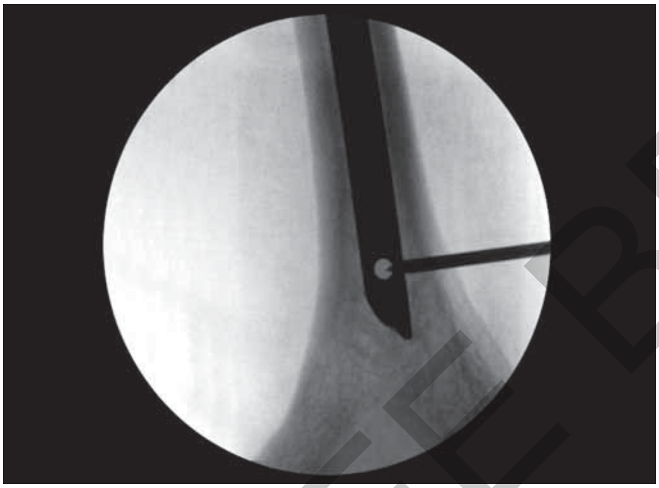


FIG. 22: K-wire making an indent in the moon of distal locking.

FIG. 23: Awl used to drill anterior cortex.

the humeral condyles properly. The tip of nail should be at least 5 mm under the subchondral bone. Nail protruding out can damage the rotator cuff and they also cause impingement and shoulder abduction restriction.

Step 10: Distal locking is done by free hand technique. Here too using the C-arm in 4.5 or 6 inch mode instead of 9 inch mode enlarges the distal interlocking hole **(Fig. 22)**. As the distal humerus is triangular, AP locking will be difficult unless all the steps are religiously followed. The assistant should hold the elbow flexed to about 60° to relax the anterior soft tissues **(Fig. 23)**. Once the level of locking marked by seeing the round moon of hole in the nail, a small skin incision is taken. Then by a hemostat artery forceps blunt dissection is done till the bone is reached and then by gradually opening this hemostat, soft tissues are retracted and separated. Then a 2-mm K-wire is passed and in the center of the hole a dent is created over the anterior cortex **(Fig. 22)**. The same K-wire can be further drilled into the hole or a awl which is used for making the interlocking drill hole can be gently hammered by rotating movements only to make the hole in the anterior cortex **(Figs. 23 and 24)**. This awl should never be hammered at the far cortex beyond the nail to prevent inadvertent iatrogenic fracture or butterfly piece coming off from the far cortex. Once the near cortex is drilled with the awl, proper drill bit is used to drill the far cortex. I normally prefer hand drill over power drill for this purpose. Then a selected bolt is passed **(Fig. 25)**. Holding the head of the bolt with a thread helps in retrieving the bolt by pulling out the thread in case sometimes the screw driver slips from the bolt head before it is locked in place.

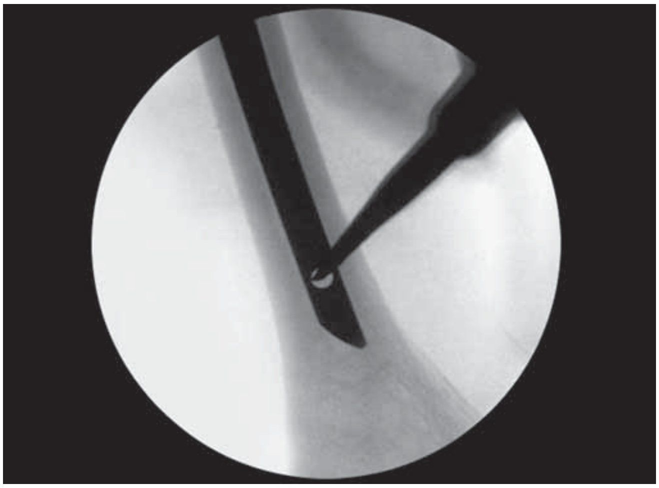


FIG. 24: Drilling of anterior cortex with awl.

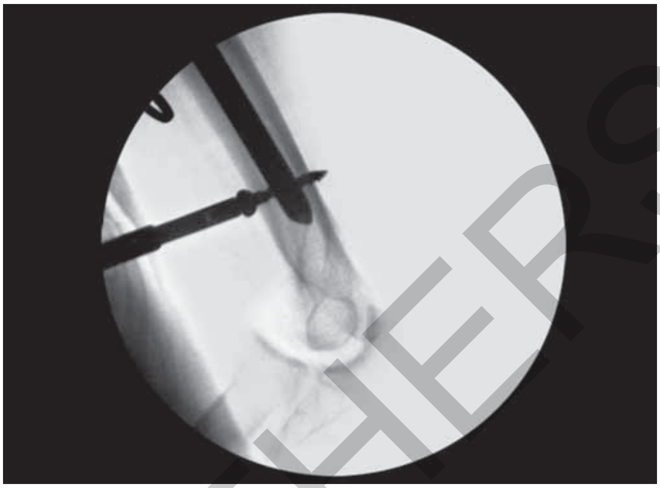


FIG. 25: Distal locking picture.

FIG. 26: Fracture site compaction technique.

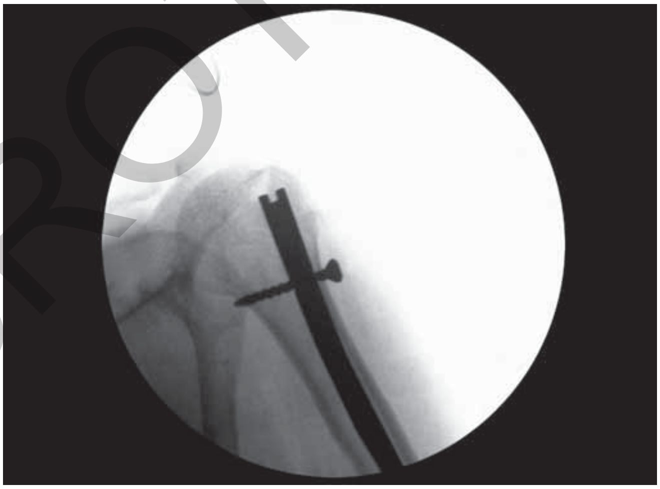


FIG. 27: Proximal locking and well-buried nail.

Step 11: Once the distal locking is completed, the fracture site is compacted by few extraction blows by attaching the extractor rod assembly **(Fig. 26)**. This technique should be used very cautiously. Too much of brute force may cause fracture site comminution. In oblique fractures and comminuted fractures, this should be done very carefully to avoid too much of shortening. And then the proximal locking is done with the help of the jig **(Fig. 27)**. In some nail systems, after doing proximal locking through the oblong hole in the nail, fracture site can be compacted by pushing this bolt down from the top by an instrument passed through the conical bolt. By all these methods, one should ensure that there is no gap left at the fracture site, especially with transverse fractures.

Nail Length Selection

Selection of the proper nail length is more critical in the humerus than in the femur or tibia. Proper proximal nail placement is approximately 5 mm below the articulating surface.

The size of the medullary cavity and the extent of humerus comminution affect the selection of nail size. A slight chance of complications due to fatigue failure does exist in the use of thin intramedullary nail. Therefore, it is recommended that the largest suitable diameter implant be used. The author does reamed nailing exclusively to insert the 7 or 8 mm nail routinely.

Preoperatively, the radiographic ruler may be placed adjacent to the contralateral unaffected humerus and viewed under image intensification to estimate the appropriate length of nail.

Assessment of Nail Length (Figs. 36 to 38)

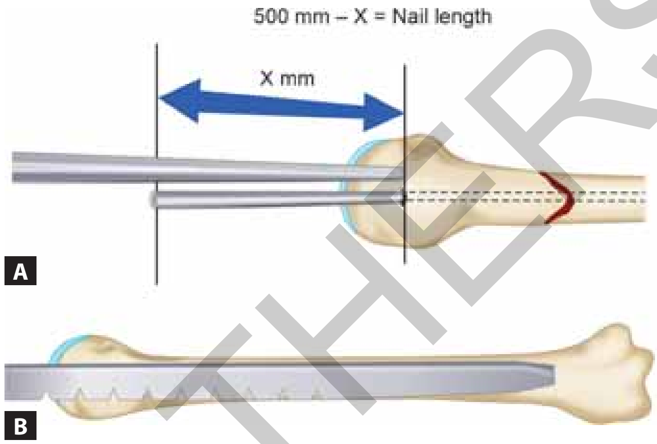
Intraoperatively, after fracture reduction, the nail length can be determined by two separate methods either by overlapping guidewires or with the use of the radiographic ruler as described in tibia **(Figs. 28A and B)**.

Guidewire Method

The position of the distal tip of the intramedullary guidewire should be approximately 1–2 cm proximal to the olecranon fossa. Now introduce the second guidewire of the same length which is inside the medullary cavity, so that its tip remains around 1 cm below the entry point into the bone. Calculate the length of the guidewire which is not overlapping remaining outside and measure this length. This is the length of the nail **(Figs. 28A and B)**.

Radiographic Ruler Method

The radiographic ruler may be placed adjacent to the affected humerus and viewed under image intensification to determine the appropriate length nail. This is the method which is used for solid nails.



FIGS. 28A AND B: Measurement of nail length: (A) Two-guidewire method and (B) Direct ruler method.

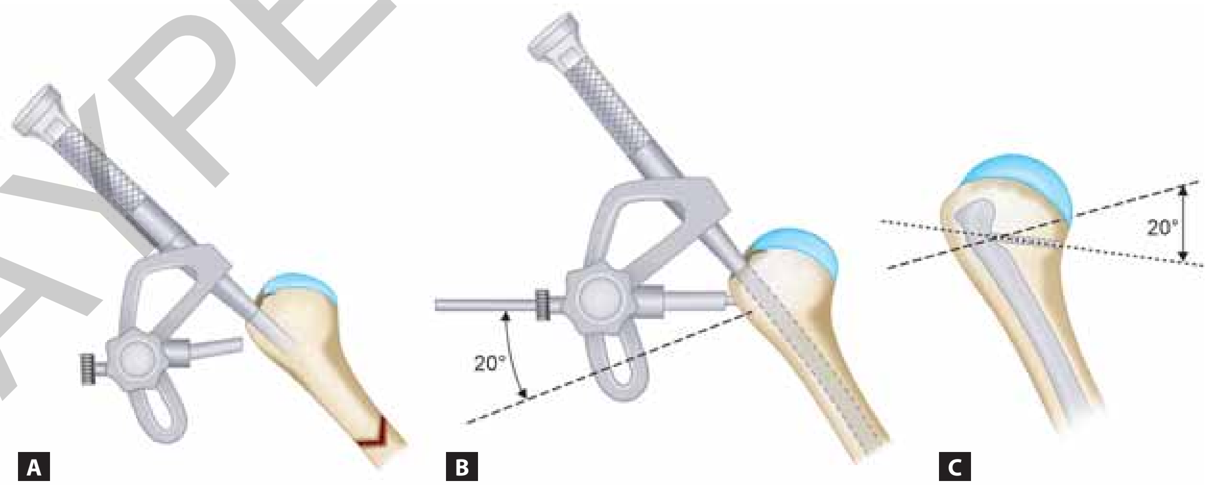
Note: Nail length should be selected to allow for impaction and still ensure that the nail's final proximal position is beneath the proximal cortex.

Reaming

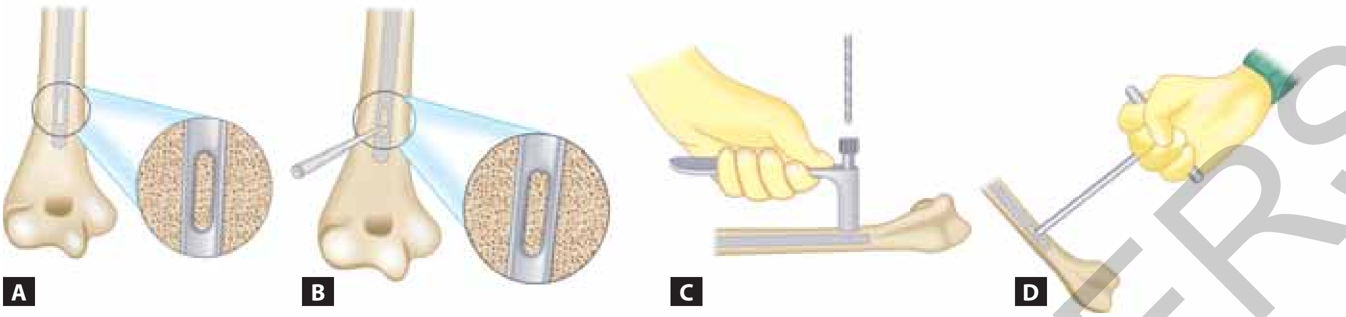
Flexible reamers with fixed reamer heads from 6 mm onwards are available exclusively for these fractures. Reaming helps in inserting thicker nail and also gives an idea about the canal size while reaming.

Nail Insertion

Proper nail placement is approximately 5 mm below the articulating surface. The nail is inserted over the guidewire in cannulated larger nail through the entry site and driven into the canal with light to moderate downward blows of the hammer. If the nail does not advance easily with each blow, remove it and ream an additional 5 mm. To avoid splitting the distal humerus, care should be taken not to overdrive the nail distally or wedge the nail tip too close to the olecranon fossa. Proximally, the humerus nail has a 2–5° lateral bend. The apex of the bend in the nail should face medially **(Figs. 29 and 30)**.

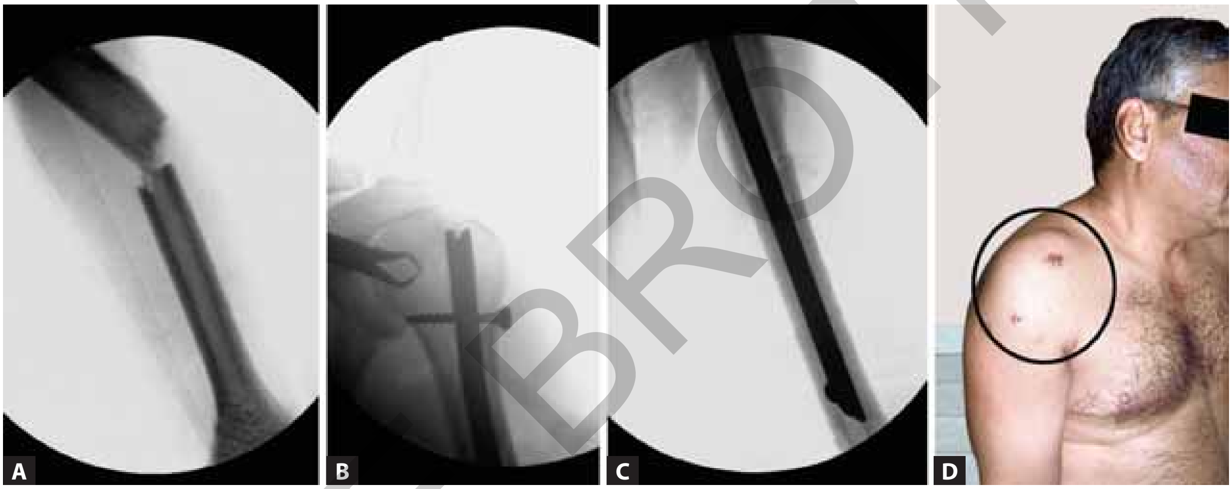


FIGS. 29A TO C: Proximal nail mounted jig.

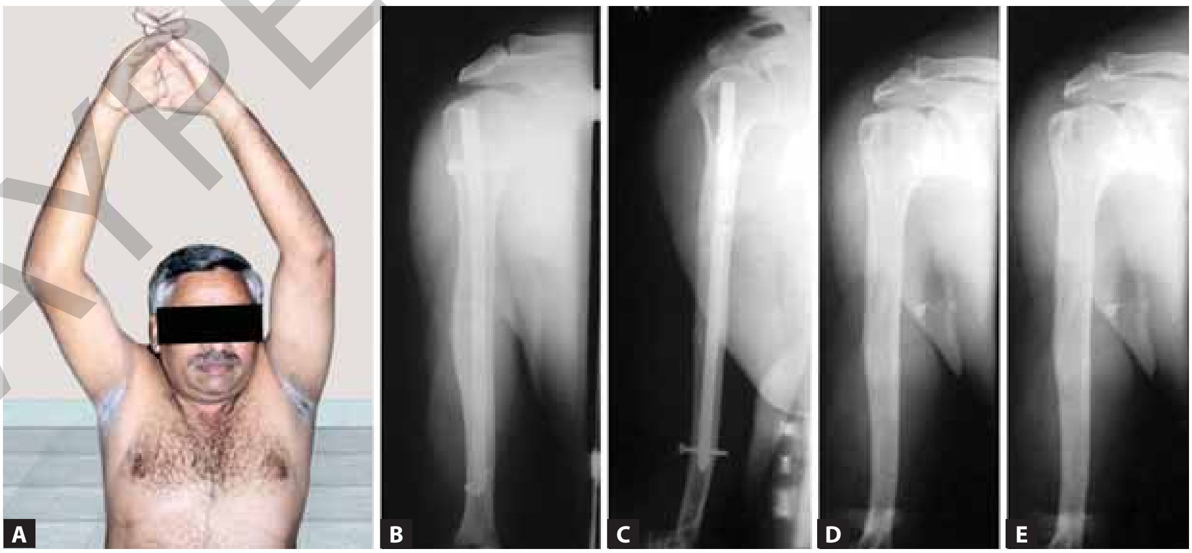


FIGS. 30A TO D: Distal locking procedure of humerus nail.

CLINICAL CASE 1 (FIGS. 31 TO 33)



FIGS. 31A TO D: Case of fracture shaft humerus treated by closed humerus nailing. Shoulder clinical picture showing the entry as well as the interlocking site scars.



FIGS. 32A TO E: Clinical picture immediate postoperative patient doing passive shoulder abduction. And 4-year postoperative X-ray showing consolidation and removal of implants done.