



Original Research Article

Tips and tricks in interlocking nailing in distal one third humerus shaft and segmental fractures of humerus

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ABSTRACT

Background: The conventional methods like conservative treatments are well accepted for managing shaft fractures of humerus. But this needs continuous frequent vigilance on the clinical and radiological follow up to see any displacements and may need to change the line of treatment requiring surgical intervention. Closed Interlocking nailing of humerus mid shaft is routinely done as frequently as open plating because of its encouraging results. Fractures of distal one third humerus shafts are challenging for nailing especially if there is comminution and segmental fracture with short distal segment.

Distal humerus fractures can be stabilised with intramedullary interlocking nails, provided adequate length is available in distal segment

The aim of this study is to explain difficulties faced in closed interlocking nailing of distal one third and below distal one third humerus shaft and solutions to overcome them and remove the hesitancy of performing nailing without any complications in such circumstances in a closed technique with minimal surgical trauma.

Materials and Methods: A prospective study of 27 patients with fracture of Humerus shaft at and below one third level fractures was done. They were treated by closed interlocking nailing in period of five years from 2014 -2019. These patients were followed up till fracture union & evaluated further postoperatively for finding its benefits over open plating.

Results: In our study, the age varied from 25 to 68 years. The mean age of patients was 45 years. 18 were males (65%) and 9 were females (35%). The results were based on type of fracture and healing period, infection, stiffness of elbow, restriction of movements. The results were encouragingly excellent in clinical radiological and functional outcome.

Conclusions: From our present study we conclude that closed nailing of distal humerus fracture is a reliable minimal invasive alternative procedures than extensive open reduction and plating. It is especially beneficial in conditions like osteoporosis, segmental fractures humerus.

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1. Introduction

Humerus fractures are common occurrence in orthopaedic practice. Incidence of fractures is 1-3% of all fractures.¹ The mechanism of injury is thought to be axial loading with varus, valgus or rotational forces. Direct trauma as in assault injuries are well known. These fractures have a bimodal incidence, occurring in young adults and elderly people.

These can be encountered due to,

1. Low energy trauma like domestic trivial fall in elderly associated with osteoporotic bones.
2. Fall from height.
3. High velocity trauma (in young adults as in road traffic accidents).
4. Assault injuries.

Hence the management of humerus fractures must be such that it leads to minimum systemic complications & maximum orthopaedic advantage. It means that early stability and near normal range of motion should be

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achieved as quickly as possible to prevent further soft tissue trauma to the area and other complications.

Though humerus shaft fractures can be treated conservatively with good results,² Plating and nailing are main surgical options commonly done and have their respective proponents with no consensus.

Plating is exclusively open surgical procedure where as Nailing is closed technique having advantage of preserving fracture haematoma and soft tissue integrity and avoiding surgical trauma. When the fracture shaft is more distal there is always a dilemma whether to nail or plate. Majority of orthopaedic surgeons find difficulty in performing nailing in distal third shaft fractures of humerus and think it easy to go for open anatomical reduction and do plating.

2. Objectives

The rationale behind choosing the present study was

1. To assess the effectiveness of antegrade nailing in distal one third and below distal third level shaft humerus fractures.
2. To put forth the tips and tricks of interlocking nailing in distal one third and below distal one third level humerus shaft fractures.
3. To evaluate clinical, radiological and functional outcome after nailing.

3. Materials and Methods

Prospective study of 27 patients was done. These were having distal third shaft fractures of Humerus with or without polytrauma & with or without co-morbidities. All patients were evaluated medically and cardiac evaluation was done in elderly patients. They were treated with antegrade nailing in a period of five years after approval from institutional ethical committee. All relevant data were collected in a standardised proforma.

3.1. Inclusion criteria

1. Humerus shaft fracture in distal one third and below level.
2. Segmental fracture shaft humerus.
3. Communitated fracture shaft having short distal segment.

Table 1:

	Fracture Geometry	Number of Cases
1	Transverse	8
2	Oblique	5
3	Comminuted	5
4	Spiral	3
5	Segmental	6
	Total	27

Of the 27 patients, 3 had open wound grade one and grade two compound, 5 had marked obesity, 5 had osteoporosis & 3 had vascular injury. Patients were ranging from 25 to 68 yrs age. Those with fracture humerus with vascular injury were treated on emergency basis by fixation of humerus fracture with antegrade interlocking nail and vascular repair was done by vascular surgeon. These patients recovered uneventfully. Co-morbid condition like Diabetes Obesity Hypertension Osteoporosis cases were also operated after complete medical evaluation.

3.2. Operative procedure

Anaesthesia: Regional anaesthesia or general anaesthesia.

Position: Antegrade humerus interlocking nailing is done in supine position on a radioluscent top table with a soft support below scapula and arm on the side to be operated.



Fig. 1: Position of arm over softarm support.



Fig. 2: Supraspinatus has to be incised sharply along its direction of fibres in one plane. Do not splay the fibres

3.3. Surgical technique

Primary scrubbing of full upper extremity including axilla with free full draping is done.

Primary screening of fractured bone is done under C-arm in AP and Lateral views to see fracture geometry and its

displacements and alignment.

1. Incision: One cm skin incision at greater tuberosity level as seen in C arm Stab incision incising skin subcutaneous tissue and incising along the length of fibres of rotator cuff. Tissue dissection should not be done with artery forceps.
2. Entry point: is just medial to Greater tuberosity. Entry is made with an cobblers awl with its tip directing parallel to medullary canal. Alternatively a thin guide wire is passed and entry is enlarged with cannulated drill or reamer.
3. A thin unbeaded guide wire is passed in the medullary canal through the entry made and checked under c arm and confirm the placement in AP and Lateral views. The guide wire is negotiated closely in distal segment under c arm with gentle traction and reduction held in position. The Guide wire should be in centre in AP view and in long axis of shaft humerus in lateral view.
4. In case of segmental fracture Check that guide wire placement is in the medullary canal in all proximal middle and distal segments under c arm in AP and Lateral views at different steps at fracture levels.
5. Once the guide wire is in medullary canal, gradual reaming is done with graduated rigid cannulated reamers or flexible reamers over the guide wire to accommodate largest diameter nail in the canal. We reamed one mm larger than the proposed diameter of nail.
6. Stop reaming at comminution site just push the reamer tip across the fracture site into distal segment and restart reaming
7. Reaming is done with end cutting and side cutting flexible reamers with fixed head reaming tips.
8. Reaming is done upto superior border of olecranon fossa to accommodate longest length of nail to have longer working length of the nail for the fracture to be stabilized.
9. It is safe to ream with rigid cannulated reamers with gentle controlled pressure.
10. Now a proper sized humerus interlocking nail assembled with jig is passed over guide wire holding the fracture site well reduced in position.
11. Safe interlocking: Use new sharp tip 2.5 mm k wire. Localize IL hole with a small 2.5 mm K-wire make a mark by gentle hammering on K-wire on to the bone and then drill it into opposite cortex. Do not hammer strongly or you may have a supracondylar fracture making simple things complicated. To avoid IL bolt being lost in surrounding soft tissue, use self retaining screwdriver with a loop of vicryl around head of IL bolt. (Figure 4 and Figure 5)
12. Distal locking was performed using a freehand technique. Before the distal screw was inserted, the fracture site is compressed by placing an axial load on

the elbow. Correct rotation is obtained by pointing the forearm and hand perpendicular to the ceiling.

13. Check under C arm that Interlocking hole is obliterated by interlocking bolt in AP and lateral views
14. Proximal interlocking is done through jig
15. Remove jig assembly and close the wounds. Apply pressure bandage from wrist to arm level to avoid oedema.
16. Humerus interlocking nails used had a diameter of 6mm, 7mm, and 8 mm in different individuals as per canal diameter could accommodate after proper reaming distal segment. In few of the patients where distal segment was long enough we could double interlock in distal segment for better stability.
17. Post-operatively a shoulder arm pouch sling is sufficient for support splinting

3.4. Postoperative management

Post operatively parenteral antibiotics were administered for three days and followed by oral antibiotics for further five days. Post-operatively a shoulder arm pouch sling is sufficient for support splinting. Pendular as well as Shoulder abduction exercises were started on second or third post-operative period as per patient tolerance. Elbow flexion extension exercises were started gradually at four to six weeks. Patients were discharged on fourth post-operative day and were advised to follow up on OPD basis for suture removal and then later every six weeks for clinical and radiological assessment till bony union. Wrist and small joints of hand of operated side were encouraged. Oral NSAIDs were prescribed for analgesic effect in post-operative period for 10 days and as and when required thereafter symptomatically. Calcium supplements were given to elderly patients.

4. Results

The functional outcome was measured by the “Disabilities of Arm, Shoulder and Hand” (DASH) Questionnaire at full recovery with bony union.

The DASH questionnaire has thirty questions the answers of which are graded from one to five points. The functional score is calculated by the formula $DASH\ DISABILITY / Symptom\ Score = \{ (sum\ of\ n\ responses) - 1 \} \times 25 / N$ Where N = number of responses. The best possible score is 0 and the worst possible score is 100. The functional outcome decreases as the score increases.

DASH scores: 0 - 20 points rated as excellent,

21 – 40 points as good,

41-60 points as fair and ≥ 61 points as poor.

The mean DASH score in the series was 30 (lower the score better the function).

We quantified pain using visual analogue scale with zero being no pain and 10 extreme pain at 10th post operative



Fig. 3: Unbeaded guide wire tip is used to ream with fixed head flexible or rigid cannulated reamer so we get additional length of distal segment



Fig. 4: Safe interlocking



Fig. 5: Safe interlocking



Fig. 6: Case 1: Short oblique fracture



Fig. 7: Segmental fracture

day and every 6 weekly follow up upto 6 months or till bony union. The VAS score was decreasing at every follow up.

Shoulder and elbow range of motion were recorded. At first follow up (6 weeks) 5 patients had restriction of abduction and flexion of shoulder joint of more than 20° . At 6 months, 23 (82%) patients had full range of shoulder movements and only three (9%) had restriction terminally. However this improved by continuous physiotherapy. Elbow range of movements were started gradually at six weeks as per fracture geometry and rigidity of fixation comminution and age and compliance of patient. Patients without comminution responded well with active flexion and extension exercises at elbow. Patients having comminuted fractures and associated fore arm bone fractures responded slowly to range of movements at elbow because

of prolonged splint age and stiffness caused thereby and some pain and intolerance by patient All patients had full range of movements at wrist and fingers.

Radiological evaluation was done at six weekly follow up till complete bony union.

4.1. Postoperative evaluation

Healing time- 12 to 16 weeks.

Infection- One case which healed up in 3 weeks later (in compound fracture case.)

Elbow stiffness- 4 patients had stiffness they had bad comminution and were splinted for longer period but could be regained by aggressive physiotherapy.

Elbow range of motion- All patients had free and full flexion and extension of elbow. In patients having



Fig. 8: Comminuted fracture with associated fore arm bone fracture



Fig. 9: Clinical function at elbow

comminution, terminal 10-20* extension motion was restricted.

No radial nerve palsy post operatively after closed interlocking nailing.

Wrist and shoulder movements were free.

5. Discussion

Due to modern lifestyle changes, the incidence of distal humerus fractures has risen and more so in association with shaft fractures of humerus because of fast world and high velocity trauma occurring in road traffic accidents.

Humerus bone is also known as funny bone. It creates humour to a treating surgeon by its mischievous behaviour responding differently to any given mode of treatment either it be conservative or surgical i.e. Plating or nailing depending upon fracture geometry type of fixation and general health of patient with associated co morbid

conditions.

Though open reduction and internal fixation with plate is widely and commonly done and is well accepted procedure, interlocking nailing of humerus has gained popularity now a days for stabilisation of humeral shaft fractures due to its load sharing nature of implant preserving fracture haematoma with minimal surgical insult to soft tissues with rigid fixation and early mobilisation.^{3,4}

The results of intramedullary interlocking nailing are increasingly encouraging and overshadowing the plate osteosynthesis procedure. There is no much significant difference between the two groups in terms of union rate, shoulder function in terms of range of movements due to rotator cuff injury occurring in nailing or any other complications.

The main concern after intramedullary nailing is limitation of range of movements and pain in shoulder

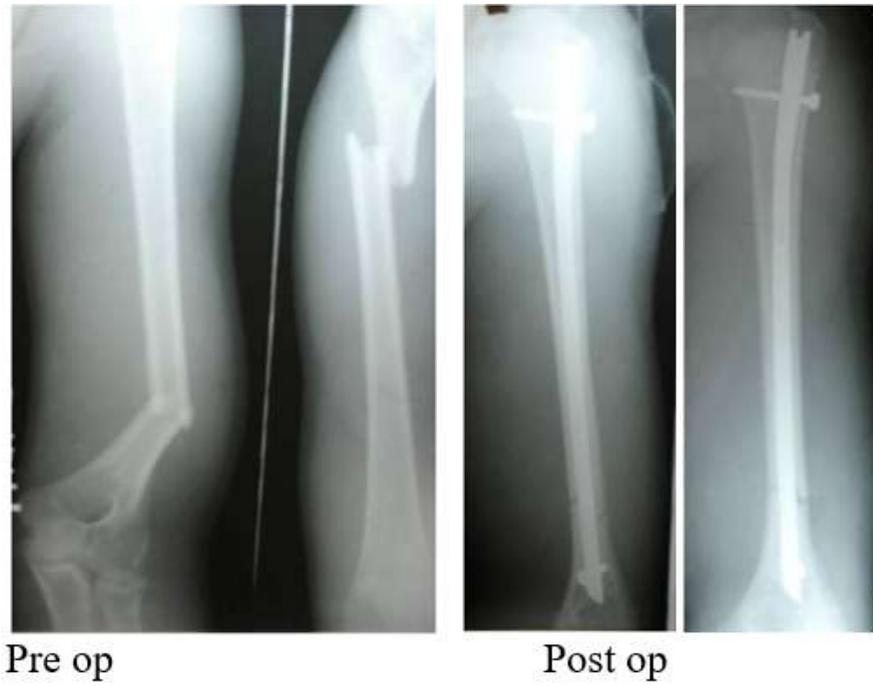


Fig. 10: Short distal segment



Fig. 11: Segmental fracture



Fig. 12: Comminuted segmental fracture



Fig. 13: Follow up full union at 9 months



Fig. 14: Clinical function at elbow and shoulder



Fig. 15: Short distal segment with oblique comminution

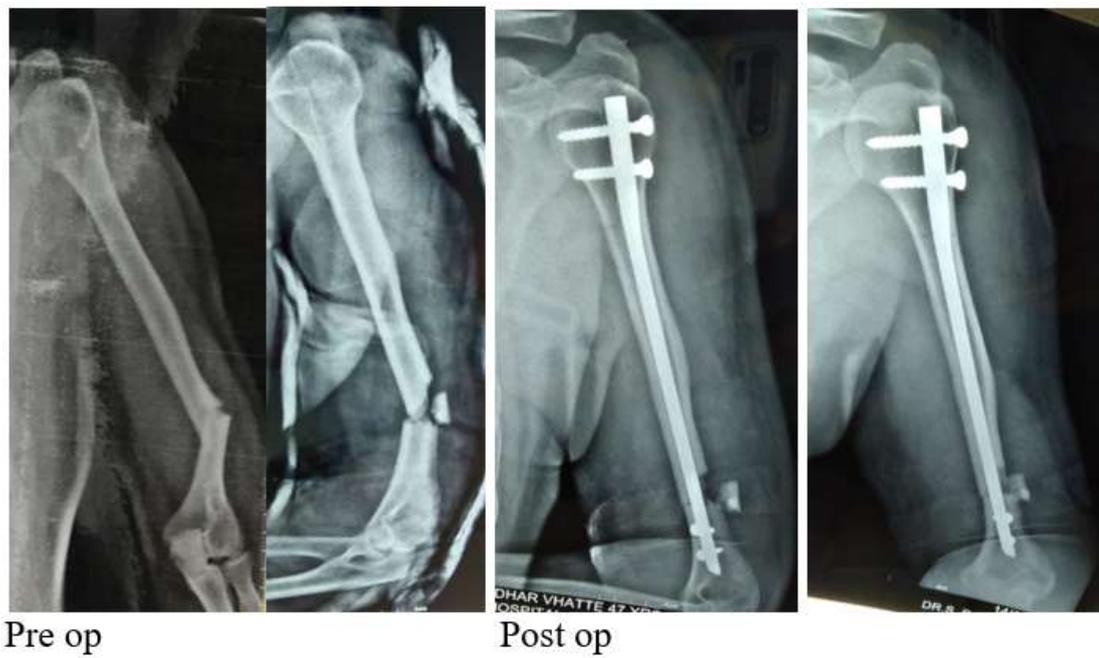


Fig. 16: Very distal fracture

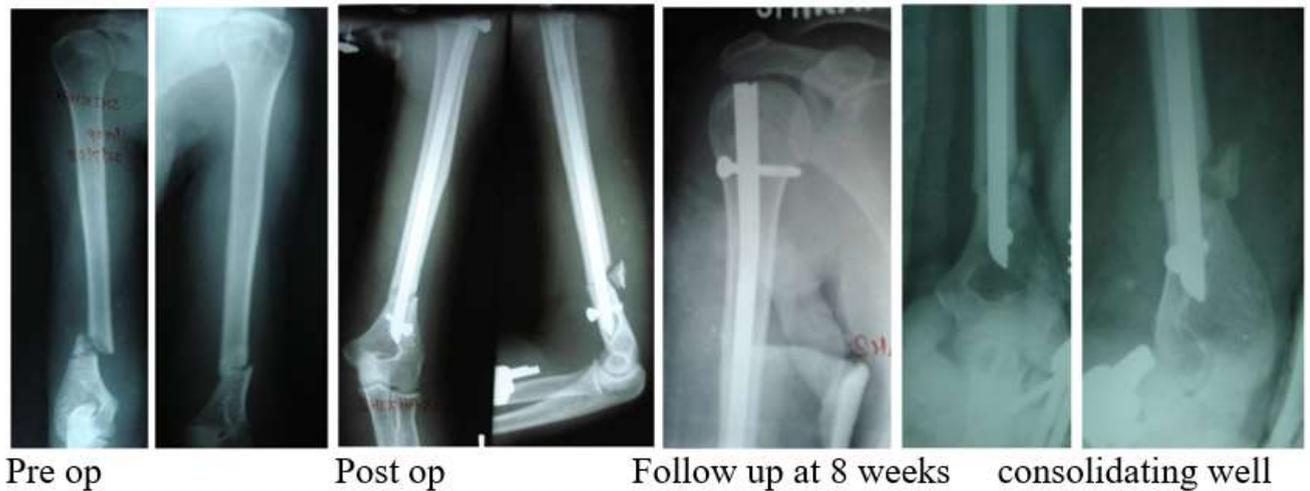


Fig. 17: Very distal fracture

which is a myth due to improper tissue handling tissue dissection during skin incision proper entry reaming and nailing occurring during nailing These all can be minimised by sharp stab incision of skin subcutaneous tissue and sharp incision of rotator cuff and taking care of it during nailing procedure. It is been heard and explained in many CMEs and conferences by esteemed nailers of humerus that any injury to rotator cuff less than 10 mm is not a concern, and the nail we pass has a diameter ranging from 6mm 7mm upto 8 mm which is less than 10 mm. The other cause are incomplete embedding of proximal nail tip keeping it proud thus causing pain attrition of rotator cuff, subacromial impingement, prominent interlocking bolt proximally due to incomplete screwing in causing limitation of range of movements of shoulder.

The main part of discussion over here is nailing in distal third shaft fractures of humerus. Interlocking nailing in distal shaft of humerus is challenging procedure.

The different factors are discussed for proper placement of nail reaming and safe interlocking in distal short segment.

Distal third shaft fractures of Humerus can be managed by Interlocking Nailing in selective cases taking proper precautions and following some principles.

Let us see what are the difficulties in interlocking nailing in distal shaft fractures of humerus.

Availability of correct size length and diameter IL nail.

Comminution at fracture site with a piece of bone in the medullary canal.

Short distal segment with comminution and angulation varus / valgus.

Segmental shaft fracture humerus with short distal segment.

Reaming the distal canal segment.

Obese patients with larger arm girth (circumference) with bulky musculature and fat and associated fracture hematoma of arm making distal interlocking difficult. The chances of IL bolt getting lost in soft tissues is maximum which again needs big incision for exploration to retrieve IL bolt.

Fixation with IL nail depends on:

Adequate length of distal segment; At least one inch of bone segment should be available above the IL hole of the nail i.e. IL hole should come at least one inch below the fracture site level. Now a days Humerus interlocking nails improved their designs having two distal interlocking holes for added stability of distal segment. We can double interlock in distal segment if the distal segment is long enough.

The anatomy of medullary canal varies along the length.

Size and shape of medullary canal of distal segment: The canal diameter is wide in Proximal third, Circular in Middle third shaft and Triangular to flattened in distal third. The nail is circular in cross-section, so due to triangular canal, nail entry in distal canal is difficult. All the more the fracture site gets distracted as we hammer or push the nail forward in distal segment. (Figure 19)

Correct size length and diameter IL nail: The more distal the level of fracture the more precise length of IL nail is required, so all sizes of lengths and diameter IL nails should be available intra-operatively on table.

Proper reaming of distal segment: Reaming of distal canal is necessary to convert triangular and flat canal into circular canal for best fitting of nail. By reaming, we get additional length of distal canal for nail and interlocking. If we do not ream the distal canal the fracture site gets distracted as we push the nail in distal segment.(Figure 20)

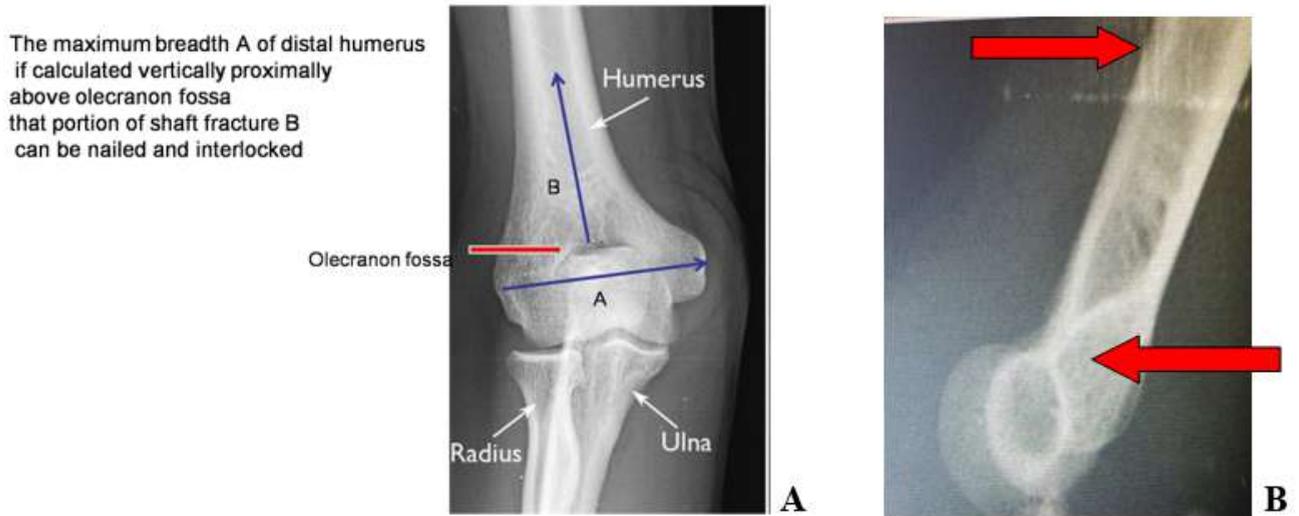


Fig. 18: The maximum breadth of distal humerus if calculated vertically above olecranon fossa that portion of shaft can be nailed and interlocked; **B:** Nailable canal

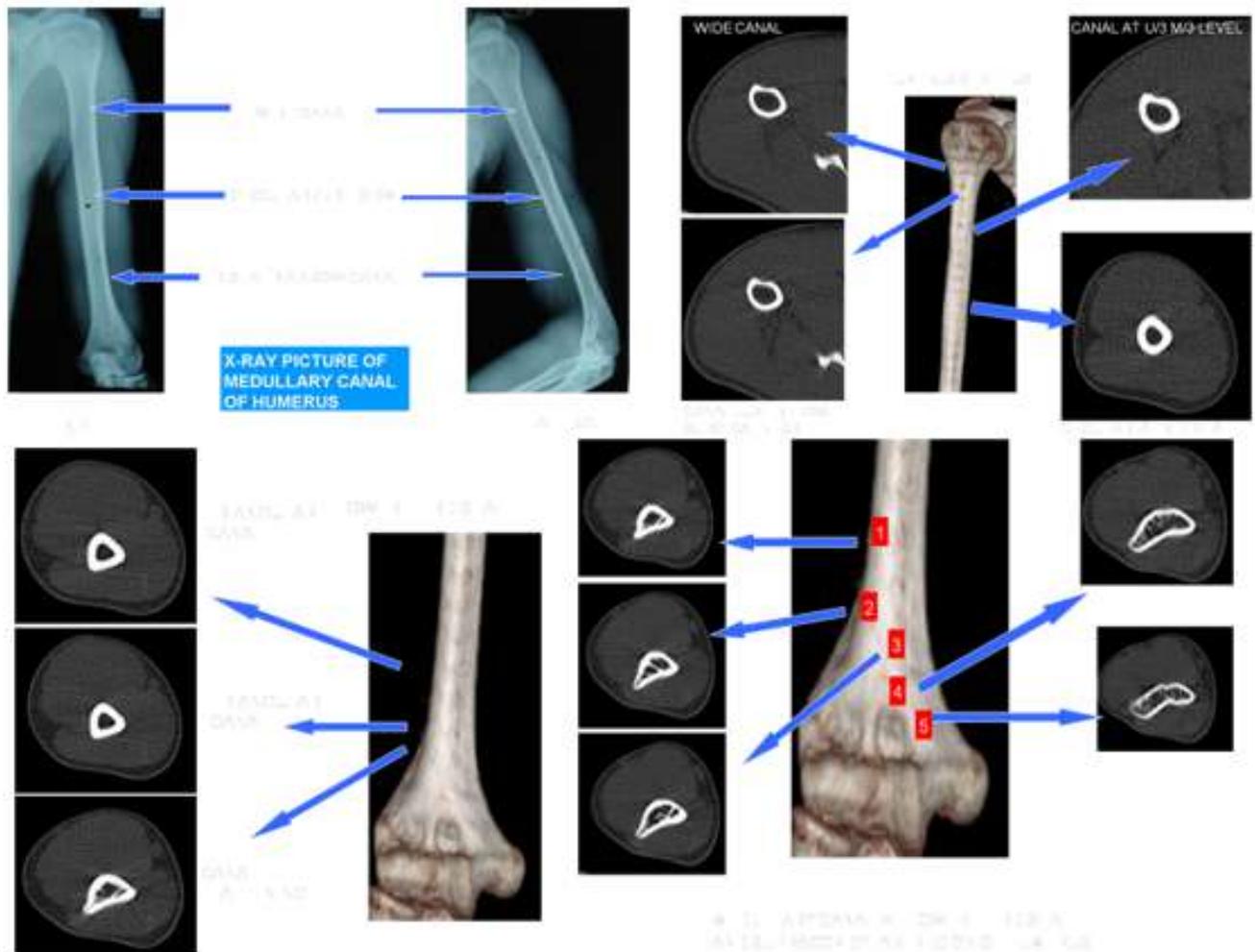


Fig. 19:

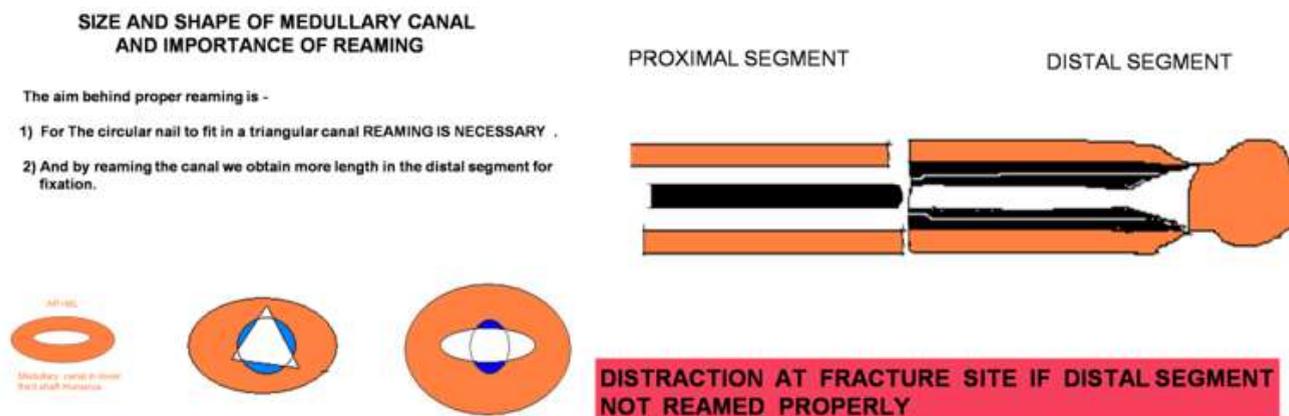


Fig. 20: Reaming distal canal to convert triangular flat canal into circular canal

Safe interlocking in distal segment: Interlocking in short distal segment must be carefully done. The anterior surface is convex and any attempt to make a hole for interlocking bolt, the drill slips away. So a sharp tip K wire is used to localize and mark the site and then drilled into opposite cortex. The k wire is never hammered as it may cause splintering or comminution in distal segment making things more complicated. Use self retaining screw drivers to hold the screw and interlock. Or a loop of vicryl knot tied to head of interlocking bolt to avoid losing it in soft tissue. Retrieval of lost bolt in obese thick arm is difficult and may need bigger incision to explore it.

Good assistant anticipating your problems is needed for this delicate precise surgery.

Operative treatment of distal humerus shaft fractures is frequently problematic, as in young patients & high energy trauma poly-trauma and comminuted fractures is a common entity. While in elderly patients osteoporotic bones or underlying implants create difficulty in management.

Conventional methods like open dynamic compression plating or locked compression plating or anterior bridge plating are routinely done.

Plating causes considerable surgical trauma & impairment of local vascularity which is reflected in high rates of septic complications^{5,6} & primary non union. Further plate provides stability from one side only hence in osteoporotic bones it is of less value whereas nail provides intramedullary support.

Mean operative time, and estimated blood loss are lower in the nailing group compared to plating.

Advantages of Humerus interlocking nailing over plating

1. Closed technique and minimally invasive procedure
2. In polytrauma patients positioning for posterior plating of distal humerus in lateral position with arm over chest position is impossible so these fractures can be nailed in supine position

3. As a quick procedure in obese patients, polytrauma, pelvic fractures and pregnancy (2nd and 3rd trimester). When positioning is difficult or not possible for some or the other reason.
4. Intramedullary implant always scores over surface implant as it acts as internal splint spanning the whole length
5. Nail being internal splint assists in day to day activities of the patient even if the fracture goes in delayed union in elderly where revision cannot be done for their predisposing co morbid medical conditions
6. Biological fixation preserves fracture haematoma avoids infection
7. All segmental humerus shaft fractures can be fixed
8. Advantageous in osteoporotic bones in elderly
9. No handling of radial nerve
10. Rotator cuff injury is not a problem as it is thought of
11. Good function at shoulder and elbow with good range of motion
12. No stress risers are seen after nailing as is seen at end of plate fixation or after removal of plate Refracture rate after plate removal is 6.9%.^{1,7}
13. Can be done through mini incision cosmetically well accepted.
14. No residual stiffness or restriction of range of movements after nailing.
15. Less operative time...less anaesthesia time... less bleeding less morbidity and cosmetically small scar

Shoulder pain and restriction of shoulder movements and risks of delayed union have been suggested as disadvantages of antegrade intramedullary fixation^{8–11} Impairment of shoulder function with antegrade interlocking nailing could be due to rotator cuff violation subacromial impingement improper embedding the nail tip proximally. Verdano et al. in a retrospective cohort of 48 patients investigating the clinical and sonographic impact on the rotator cuff (RC) of the use of the anterolateral approach for nailing found

no significant clinical/ sonographic impact on the rotator cuff.¹² In this series according to Constant–Murley score, shoulder function was good to excellent in 95%.¹³ Average ASES score was 93.3%. Many recent reports have reported similar shoulder dysfunction rates (rated according to ASES and or Constant–Murley scoring) less than 10% and have recommended medial entry point avoiding the avascular area of the cuff, meticulous surgical dissection, static locking of the nail to prevent backing out and complete embedding of the nail as technical tips to minimize cuff related problems and consequent shoulder dysfunction.^{14,15}

6. Conclusion

Distal one third humerus fractures with short segment in those cases where there is adequate canal to accommodate nail can be very well treated by closed interlocking nail following the tips and tricks with excellent clinical radiological and functional outcome. Nailing is reliable alternative for conventional procedures than extensive open reduction and plating. The rotator cuff injury can be minimised by careful sharp incising and less tissue handling at entry point of nail and proper embedding of nail tip proximally with good rehabilitation post operatively. In comminuted cases elbow mobilisation should be gradual depending on stability of fixation, osteoporosis, age of patients and patient compliance.

7. Source of Funding

None.

8. Conflict of Interest

None.

9. Acknowledgement

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