ORIGINAL RESEARCH PAPER

Orthopaedics

KEY WORDS: Intramedullary nailing; humerus fracture; proximal humerus; humeral shaft fracture; rotator cuff integrity; Constant score; ultrasonography; shoulder function.

ROTATOR CUFF INTEGRITY AND SHOULDER FUNCTION AFTER INTRAMEDULLARY HUMERUS NAILING: A PROSPECTIVE COMPARATIVE STUDY OF PROXIMAL HUMERUS AND HUMERAL SHAFT FRACTURES

Dr. Akash Gupta 3rd Year Junior Resident, Department of Orthopaedics, Index Medical College Hospital and Research Centre, Indore (MP)

Dr. Priyanshi Brijpuria* 3rd Year Junior Resident, Department of Anaesthesia*Corresponding Author

Dr. Yashika Demba 3rd Year Junior Resident, Department of Orthopaedics

ABSTRACT

Background: Antegrade intramedullary nailing (IMN) is widely used for proximal humerus and humeral shaft fractures because it provides stable fixation with limited soft-tissue stripping. However, concern persists regarding iatrogenic rotator cuff injury and its impact on postoperative shoulder function. This study compared rotator cuff integrity and functional outcomes after IMN in proximal humerus fractures versus humeral shaft fractures. **Methods:** A prospective comparative study was conducted in the Department of Orthopaedics, Index Medical College Hospital and Research Centre, Indore, over 18 months. Forty adult patients undergoing IMN for humeral fractures were included: proximal humerus fractures (n=24) and humeral shaft fractures (n=16). Preoperative assessment included clinical examination, radiographs, and ultrasonographic evaluation of the ipsilateral rotator cuff. Patients were followed clinically and radiologically until fracture union. Functional outcome was assessed using Constant-Murley score, shoulder range of motion, and Subjective Shoulder Value (SSV). Rotator cuff integrity was reassessed by ultrasonography at follow-up. Statistical analysis was performed using SPSS; $p<0.05$ was considered significant. **Results:** Mean age was comparable between the proximal and shaft groups (58.92±13.86 vs 55.19±14.51 years; p=0.412). Proximal fractures were more often associated with low-energy trauma, whereas shaft fractures were more commonly due to high-energy trauma. Union rates were excellent in both groups, although shaft fractures united significantly earlier (13.69±2.71 vs 15.63±2.78 weeks; p=0.018). Functional outcome favored shaft fractures, with significantly higher Constant score (83.50±6.91 vs 77.42±7.81; p=0.004), better elevation and external rotation, and higher SSV (82.81±6.02 vs 77.92±6.41; p=0.015). Rotator cuff integrity was preserved in the majority of patients in both groups, with no significant difference in postoperative ultrasonographic abnormalities. Complications were infrequent and comparable between groups. **Conclusion:** Intramedullary humerus nailing provides reliable fracture union, low complication rates, and satisfactory shoulder outcomes in both proximal humerus and humeral shaft fractures. Rotator cuff integrity was preserved in most patients. Humeral shaft fractures demonstrated faster union and superior functional recovery compared with proximal humerus fractures.

INTRODUCTION

Humeral fractures account for a substantial proportion of upper-limb trauma, with proximal humerus fractures occurring commonly in older patients after low-energy falls and shaft fractures often following high-energy trauma in younger adults. Intramedullary nailing has gained popularity because it offers load-sharing fixation, limited periosteal stripping, smaller incisions, and earlier rehabilitation. Despite these advantages, antegrade humeral nailing remains controversial because the nail entry point traverses the rotator cuff, especially the supraspinatus tendon, potentially resulting in postoperative pain, weakness, and restricted shoulder motion.

Preservation of rotator cuff integrity is therefore central to the success of humeral IMN. While fracture union is important, the true functional outcome also depends on pain relief, range of motion, strength, and patient-perceived recovery. Ultrasonography provides a practical method for postoperative assessment of rotator cuff integrity because it is inexpensive, dynamic, and free of metal artefact.

The present study was undertaken to evaluate rotator cuff integrity and shoulder function after intramedullary nailing of humeral fractures and to compare outcomes between proximal humerus fractures and humeral shaft fractures.

AIMS AND OBJECTIVES

Aim

To evaluate rotator cuff integrity and shoulder function after intramedullary nailing of humeral fractures and to compare outcomes between proximal humerus fractures and humeral shaft fractures.

Objectives

1. To assess rotator cuff integrity following intramedullary nailing using ultrasonography.
2. To compare functional outcomes between proximal humerus fracture and humeral shaft fracture groups using Constant-Murley score, range of motion, and Subjective Shoulder Value.
3. To compare fracture union and postoperative complications between the two groups.
4. To review the available literature regarding rotator cuff integrity after antegrade humeral nailing.

MATERIALS AND METHODS

Study Design & Setting

The current study was a prospective clinical study that was done in the Department of Orthopaedics, Index Medical College, Hospital and Research Centre, Indore. The objective of the study was to examine the integrity of the rotator cuff and shoulder functioning in intramedullary nailing on the humerus with an ultimate desire to reduce the complications witnessed with previous models. The entire duration of the study was 18 months from June 2024 to December 2025; the period covered the following, Patient recruitment, Surgical management, Postoperative follow-up, and Data analysis.

40 adult patients with humeral fractures treated by intramedullary nailing were enrolled. Patients were divided into proximal humerus fracture group (n=24) and humeral shaft fracture group (n=16).

Inclusion Criteria

1. Were aged ≥18 years.
2. Belonged to either gender.

3. Fractured proximal humerus and humoral shafts had intramedullary repair done.
4. Introduced with proximal humur displacement that is based on the Neer criteria (displacement must be 1 cm or 45 o angulation between the head and shaft).

Exclusion Criteria
1. Age <18 years.
2. Polyarthritis, e.g. rheumatoid arthritis.
3. Ipsilateral rotator cuff tear/abnormalities.
4. Generalized joint laxity.
5. Pre-traumatic ipsilateral shoulder stiffness.
6. Past having of ipsilateral shoulder operations.
7. Intra-articular extensional fractures.

Preoperative Evaluation
1. Clinical Evaluation: A structured case record format was used to note out all details of the history and clinical examination findings.

2. Radiological Investigations:
- Digital X-ray (anteroposterior and lateral) of the proximal humerus and the humoral shaft.
- Preoperative ipsilateral shoulder joint X-ray.

3. Ultrasonography (USG): USG of the ipsilateral shoulder joint was carried out to determine the initial rotator cuff integrity.

4. Routine Investigations: Anesthetic fitness was conducted by routine preoperative investigations (hemoglobin, hematocrit, coagulation profile, tests of renal functions, ECG, chest X-ray).

Surgical Procedure
- A standardized protocol of intramedullary nailing was carried out on all the patients.

Anaesthesia & Positioning
- The operations were carried out by use of general or regional anaesthesia.
- The patients were positioned in either the supine position or beach-chair position depending on the required surgery.

Surgical Technique
1. Under C-arm, the top of the humeral head was localized using a needle or 1.8 mm K-wire.

2. The cannulated square awl was used to make a pilot hole and act as a joystick to minimize the epiphyseal fragment and position it identically with the shaft.

3. When the reduction was made the guide stem was inserted into the shaft through the awl.

4. A cannulated reamer was used in enlarging the entry portal.

5. The cannulated nail was inserted and its height assuring is verified with the C-arm (3 5 mm below cartilage).

6. The rotation of nails was tested by matching the jig with the forearm.

7. The stage of distal locking was done with1- 2 bicortical screws.

8. A hammer was used to strike retrograde on fracture site.

\9. The proximal locking was done with 1-2 screws.

10. In the humeral shaft fractures, medullary canal was reamed in advance and nails were inserted.

Postoperative Management
1. Exercises of self-mobilization of the pendulum were introduced on day 1.
2. On day 15, formal physiotherapy was started.
3. Patients were discharged after being made stable and taught about physiotherapy and follow up.

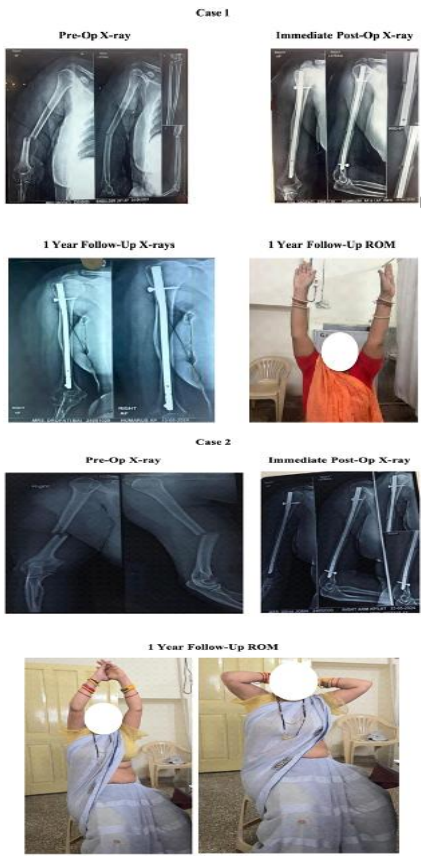
Follow-Up Protocol
Patients were followed up:
Daily during hospital stay,
At 2 weeks postoperatively,
Every 4-weeks thereafter until 38-40 weeks or until union.

Patients were assessed at every follow up and measured on:
- Physical (pain, range of motion, stability) examination
- Radiological examination (healing of fractures, implantation)
- USG assessment (rotator cuff integrity).

Data Collection
Demographic details (age, sex, occupation, residence).
Clinical features and history.
General and local examination findings.
Radiological and USG reports.
Operative details.
Postoperative complications.
Functional and radiological outcomes at each follow-up.

Outcome Measures
1. Primary Outcomes:
- Rotator cuff integrity (pre- and post-operative USG).
- Shoulder function (Constant-Murley score, pain, mobility).

2. Secondary Outcomes:
- Incidence of complications (stiffness, pain, implant-related issues).
- Time to union.
- Patient satisfaction and return to daily activities.



Case 3

Pre-Op X-ray

Immediate Post-Op X-ray

3 Months Follow-Up ROM

1 Year Follow-Up ROM

Statistical Analysis

Data were entered into SPSS version 25.0 for analysis. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used. Comparative analyses were performed to assess differences between pre- and post-operative outcomes. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 40 patients: 24 with proximal humerus fractures and 16 with humeral shaft fractures. The proximal group was slightly older, but the difference was not statistically significant (58.92±13.86 vs 55.19±14.51 years; p=0.412). Gender distribution and BMI were comparable between groups. Proximal fractures were more frequently associated with low-energy trauma, whereas shaft fractures were more commonly related to high-energy trauma.

Operative parameters favored the shaft fracture group. Time to surgery was comparable, but proximal fractures required longer operative time and were associated with greater intraoperative blood loss, reflecting the greater complexity of proximal humerus fixation.

Union rates were excellent in both groups. Shaft fractures united significantly earlier than proximal fractures (13.69±2.71 vs 15.63±2.78 weeks; p=0.018). Complications were infrequent in both groups; varus malalignment, tuberosity malunion, and hardware prominence were slightly more common in proximal fractures, but the differences were not statistically significant.

Functional outcome was significantly better in the shaft fracture group. Mean Constant score was 83.50±6.91 in shaft fractures compared with 77.42±7.81 in proximal fractures (p=0.004). Shoulder elevation and external rotation were also significantly higher in shaft fractures (elevation 153.94±9.42° vs 141.25±11.83°, p=0.001; external rotation 51.25±8.11° vs 43.58±8.72°, p=0.006). Subjective Shoulder Value was significantly higher in shaft fractures (82.81±6.02 vs 77.92±6.41;p=0.015).

Ultrasonographic evaluation demonstrated preserved rotator cuff integrity in most patients. At 3 months, normal cuff was seen in 79.17% of proximal fractures and 87.50% of shaft fractures; at 6 months, the corresponding figures were 87.50% and 93.75%. Partial tears were uncommon and no full-thickness tears were observed. The difference in cuff integrity between groups was not statistically significant.

Parameter	Proximal humerus (n=24)	Shaft humerus (n=16)
Mean age (years)	58.92 ± 13.86	55.19 ± 14.51
Time to union (weeks)	15.63 ± 2.78	13.69 ± 2.71
Constant score	77.42 ± 7.81	83.50 ± 6.91
Elevation (°)	141.25 ± 11.83	153.94 ± 9.42
External rotation (°)	43.58 ± 8.72	51.25 ± 8.11
Subjective Shoulder Value	77.92 ± 6.41	82.81 ± 6.02
Normal rotator cuff at 6 months	21 (87.50%)	15 (93.75%)

DISCUSSION

This study demonstrates that intramedullary nailing is an effective option for both proximal humerus and humeral shaft fractures, providing high union rates and low complication rates. However, functional recovery was superior in shaft fractures. This is likely related to the fact that proximal fractures involve the shoulder joint more directly, require more complex reduction, and are more likely to disturb the rotator cuff–tuberosity complex and surrounding soft tissues.

The significantly faster union seen in shaft fractures may reflect more favorable cortical contact and biomechanical loading conditions in the diaphysis, whereas proximal fractures involve cancellous bone and more complex fracture geometry. The better Constant score, range of motion, and SSV in shaft fractures suggest that preservation of normal shoulder biomechanics is easier when the fracture is away from the proximal humerus.

A key finding of the present study is that rotator cuff integrity was preserved in the majority of patients in both groups. Only a small proportion of patients demonstrated partial cuff tears on postoperative ultrasonography, and there was no significant difference between proximal and shaft fractures. This supports the view that when antegrade intramedullary

nailing is performed with careful technique, significant rotator cuff morbidity can be minimized.

The present findings are broadly consistent with previous reports showing good union and acceptable shoulder outcomes after modern humeral nailing, while also confirming that proximal humerus fractures may have somewhat inferior functional recovery than shaft fractures because of their closer relationship to the glenohumeral joint and rotator cuff.

CONCLUSION

Intramedullary nailing is a safe and effective treatment for both proximal humerus and humeral shaft fractures. It provides excellent fracture union, low complication rates, and satisfactory postoperative shoulder function. Rotator cuff integrity was preserved in most patients, indicating that antegrade nailing does not necessarily compromise cuff function when performed with appropriate technique. Nevertheless, patients with humeral shaft fractures showed faster union and superior functional recovery, including higher Constant score, better range of motion, and better patient-reported shoulder value, compared with patients with proximal humerus fractures.

LIMITATIONS

1. Small sample size limited the ability to detect subtle differences between groups.
2. Single-center design may reduce generalizability.
3. Follow-up duration was relatively short for assessment of long-term cuff morbidity and implant-related complications.
4. Functional outcome was assessed mainly with Constant score, range of motion, and SSV; more detailed patient-reported outcome measures were not included.

REFRENCES

1. Muccioli C, Chelli M, Caudal A, Andreani O, Elhor H, Gauci MO, et al. Rotator cuff integrity and shoulder function after intra-medullary humerus nailing. Orthop Traumatol Surg Res. 2020;106(1):17-23.
2. Dilisio MF, Nowinski RJ, Hatzidakis AM, Fehringer EV. Intramedullary nailing of the proximal humerus: evolution, technique, and results. J Shoulder Elbow Surg. 2016;25(5):e130-e138.
3. Boileau P, d'Ollonne T, Bessière C, Wilson A, Clavert P, Hatzidakis AM, et al. Displaced humeral surgical neck fractures: classification and results of third-generation percutaneous intramedullary nailing. J Shoulder Elbow Surg. 2019;28(2):276-287.
4. Gracitelli MEC, Malavolta EA, Assunção JH, Matsumura BA, Kojima KE, Ferreira Neto AA. Ultrasound evaluation of the rotator cuff after osteosynthesis of proximal humeral fractures with locking intramedullary nail. Rev Bras Ortop. 2017;52(5):601-607.
5. Lopiz Y, Garcia-Coiradas J, Garcia-Fernandez C, Marco F. Proximal humerus nailing: a randomized clinical trial between curvilinear and straight nails. J Shoulder Elbow Surg. 2014;23(3):369-376.
6. McCormack RG, Brien D, Buckley RE, McKee MD, Powell J, Schemitsch EH. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. J Bone Joint Surg Br. 2000;82(3):336-339.
7. Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fractures: a meta-analysis. Acta Orthop. 2006;77(2):279-284.
8. Mocini F, Rovere G, De Mauro D, De Sanctis EG, Smakaj A, Maccauro G, et al. Newer generation straight humeral nails allow faster bone healing and better functional outcome at mid-term. J Orthop Surg Res. 2021;16:631.
9. Shashikumar MS, Shetty GK, Abhishek M, Shetty DT. Ultrasound evaluation of the rotator cuff after osteosynthesis of humeral shaft fractures with interlocking intramedullary nail: a prospective interventional study. J Clin Diagn Res. 2022;16(8):RC01-RC05.
10. Mahmoud HF, Farhan AH, Fahmy FS. Assessment of shoulder function after internal fixation of humeral diaphyseal fractures in young adults: a prospective comparative study. Adv Orthop. 2021;2021:9471009.