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Original Research Article

A Comparative Study on Locking Plate versus Intramedullary Nail in the Management of Proximal Humerus Fractures

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Abstract

Background: Proximal humerus fractures make up about 5% of all fractures, with a higher occurrence in older adults due to osteoporosis. Non-displaced fractures can be treated with conservative methods, but displaced fractures need surgery. Two main fixation methods, locking plates and intramedullary nails, are commonly used in orthopedic practice, but there is still debate about which is more effective. Locking plates offer better control in the metaphysis with fixed-angle constructs, while intramedullary nails provide biological fixation with less disruption to soft tissue. This study aimed to compare functional outcomes, complication rates, and radiological union between these two techniques in an Indian population.

Methods: A prospective comparative cohort study was carried out over 18 months at the Department of Orthopedic Surgery from January 2023 to June 2024. Seventy-five patients with displaced proximal humerus fractures (Neer classification II-IV) were assigned to either locking plate fixation (n=37) or intramedullary nail fixation (n=38). We measured functional outcomes using the Constant-Murley Score and the American Shoulder and Elbow Surgeons (ASES) score at 6 weeks, 3 months, 6 months, and 12 months. Secondary outcomes included the rates of radiological union, complication rates, need for revision surgery, and time to union. We performed statistical analysis with independent t-tests for parametric data, Mann-Whitney U tests for non-parametric data, and Chi-square tests for categorical data ($p < 0.05$).

Results: At 12 months, the mean Constant-Murley score was 76.2±8.4 for the locking plate group and 74.8±9.1 for the intramedullary nail group (p=0.436). The ASES scores were 78.4±7.6 for locking plates and 76.9±8.3 for intramedullary nails (p=0.352). Radiological union was seen in 94.6% of locking plate cases and 92.1% of intramedullary nail cases (p=0.601). Varus collapse occurred in 8.1% of locking plate cases compared to 5.3% for intramedullary nails (p=0.486). Revision surgery was necessary for 5.4% of the locking plate group and 7.9% of the intramedullary nail group (p=0.512). Both groups showed similar functional recovery and acceptable complication rates.

Conclusion: Both locking plate and intramedullary nail fixation are effective surgical options for displaced proximal humerus fractures, with similar functional outcomes and complication rates. Treatment should be tailored to the individual, considering fracture complexity, bone quality, and the surgeon's expertise. These results support using both techniques as primary surgical options in Indian orthopedic practice, providing evidence-based outcomes that facilitate a return to daily activities and work.

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Introduction

Study Rationale and Background: Proximal humerus fractures are the most common upper arm fractures requiring surgery in patients over 60. The incidence is about 50 to 73 per 100,000 person-years in developed countries, and it's increasing in India due to an aging population. These injuries are more common in older adults because of a higher risk of falls, osteoporosis, and slower reflexes during falls. Younger patients usually get these injuries from high-energy events like car accidents or falls from heights.

In the past, the standard treatment for proximal humerus fractures was conservative management with physiotherapy. However, several studies have shown that displaced fractures (more than 10mm displacement or over 45° angulation) and severely broken bones benefit significantly from surgery.

The main benefits of surgical fixation include restoring proper alignment, allowing for early movement to prevent stiffness, preserving the rotator cuff, and improving overall function. Early movement lowers the risk of adhesive capsulitis and frozen shoulder, which can occur in 25 to 40% of displaced fractures treated conservatively.

Two main surgical methods have become standard in current orthopedic practice: proximal humerus locking compression plates and intramedullary nailing. Locking plates provide strong fixation with fixed-angle screws that hold everything in place, regardless of bone quality.

They are especially useful for comminuted fractures and weak bones. The lateral position of the plate helps restore medial support and align the tuberosities. In contrast, intramedullary nailing offers load-sharing fixation while preserving blood supply around the bone, causing less soft tissue damage, and allowing for early mobilization. The placement inside the bone gives added stability against rotational forces.

Even though both techniques are widely used around the world, high-quality comparative studies from Indian orthopedic centers are still limited. International studies show mixed results. Some suggest locking plates lead to better function, while others report fewer complications with intramedullary nailing. Differences in fracture types, patient age, bone quality, and surgical skill call for studies that focus on specific regions.

Aims of the Study

This study aimed to compare locking plate fixation and intramedullary nail fixation for displaced proximal humerus fractures by looking at:

1. Functional shoulder outcomes measured by standardized scoring systems at regular intervals after surgery (primary outcome)
2. Rates of radiological union and the time it takes for heal
3. Intraoperative and postoperative complications, including varus collapse, avascular necrosis, and rotator cuff issues.
4. Requirements for revision surgery and re-intervention
5. Patient satisfaction and functional restoration for return to activities of daily living and work
6. Identification of subgroups (age, fracture type) where one technique may be superior

Methods

Study Design and Setting: Prospective comparative cohort study conducted at Department of Orthopedic Surgery. The study period was 18 months, from January 2023 to June 2024. Institutional ethics committee approval was obtained prior to commencement.

Selection of Participants

Inclusion Criteria:

- Age 18 to 75 years
- Proximal humerus fractures classified as Neer type II (two-part), III (three-part), and IV (four-part) or AO/Orthopaedic Trauma Association classification types B and C
- Displaced fractures defined as >10 mm displacement or >45° of angulation at the surgical neck or greater tuberosity
- Fractures requiring surgical intervention
- Surgical intervention performed within 3 weeks of injury
- Adequate soft tissue quality for fixation (no massive soft tissue loss)
- Ability to comply with follow-up protocol for minimum 12 months
- Willingness to provide written informed consent

Exclusion Criteria:

- Age <18 years or >75 years
- Neer type I (non-displaced) fractures
- Pathological fractures (tumoral or metabolic origin)
- Open fractures with Gustilo classification >IIIa
- Severe neurovascular compromise at presentation requiring vascular intervention
- Previous ipsilateral shoulder surgery or shoulder fusion
- Posterior shoulder dislocation associated with fracture
- Severe osteoporosis (Bone Mineral Density T-score <-3.5)
- Active infection or osteomyelitis at surgical site
- Significant comorbidities contraindicating surgery (American Society of Anesthesiologists grade >3)
- Polytrauma with life-threatening injuries
- Presence of tuberosity nonunion at baseline

Participant Allocation: Participants who met the inclusion criteria were enrolled and assigned to one of two treatment groups based on the surgeon's preference, patient factors, and fracture type. Group A received locking plate fixation (n=37), while Group B received intramedullary nail fixation (n=38). Both groups were similar in age, gender, dominant arm involvement, fracture type, and timing of surgery. There was no formal randomization; the allocation was guided by clinical judgment and discussions with patients about the pros and cons of each technique.

Interventions

Group A: Locking Plate Fixation (n=37)

- Implant: Proximal Humerus Locking Compression Plate (PHILOS plate) or similar

locking plate system, 3.5 mm dynamic compression plate with fixed-angle screws.
- Surgical approach: Anterolateral deltoid-splitting approach.
- Plate positioning: Lateral surface of the proximal humerus, placed in the lateral column just above the insertion of pectoralis major. Maintain a distance of at least 5-8 mm from the greater tuberosity to prevent subacromial impingement.
- Screw configuration: At least 3-4 proximal angular screws (polyaxial) in the metaphyseal region. Capture 2-3 diaphyseal cortices distally for a minimum of 6 cortices (3 cortices equal 2 screws) of fixation.
- Greater tuberosity reduction: If fractured, reduce anatomically and secure with plate screws or separate lag screws before plate fixation.
- Rotator cuff repair: Conducted when cuff tears are found during surgery.

Group B: Intramedullary Nail Fixation (n=38)

- Implant: Humeral intramedullary nail (appropriate system: specialized proximal humerus IM nail), titanium alloy, diameter 7-9 mm selected based on the width of the intramedullary canal
- Surgical approach: Lateral acromial approach with splitting of the deltoid muscle
- Nail positioning and locking: Entry point at the lateral side of the humeral head in the subacromial space; nail inserted with proper alignment of fracture fragments; proximal locking with 2-3 angled screws capturing the humeral head; distal locking with 1-2 screws at least 6 cm below the fracture site
- Tuberosity management: Reduced and secured with tension band wiring or sutures instead of nail fixation when separately displaced
- Rotator cuff repair: Carried out when cuffs tears were found or when the tuberosity lifted during nail insertion
- Nail prominence management: Recorded and handled with burring if it caused subacromial impingement

Standardized Rehabilitation Protocol (Both Groups):

- Immediate postoperative period (0-6 weeks): Use an arm sling for 3-4 weeks. Start passive range of motion exercises 3-4 days after surgery, with help from a physiotherapist. This includes pendulum exercises, passive flexion, and passive external rotation while lying down. Begin gradual active-assisted range of motion at 2 weeks.
- Intermediate phase (6-12 weeks): Continue active range of motion. Start isotonic strengthening for the rotator cuff at 6-8 weeks. Introduce gradual resistance exercises. Keep attending physiotherapy 2-3 times a week.
- Late phase (12 weeks onward): Enjoy unrestricted active range of motion. Focus on progressive resistive strengthening. Return to functional activities. Sports and heavy labor are allowed after 12-16 weeks, depending on imaging and functional assessment.
- All patients followed standardized physiotherapy protocols, which were documented and monitored by the physiotherapy department at the institution.

Methods of Measurement

Primary Outcome Measures:

- Constant-Murley Shoulder Score (0-100 points)
- American Shoulder and Elbow Surgeons (ASES) score (0-100 points)
- Assessed at 6 weeks, 3 months, 6 months, and 12 months postoperatively

Secondary Outcome Measures:

- Union assessment: Radiological union defined as [specify criteria, e.g., bridging callus on three cortices on anteroposterior and lateral radiographs]
- Time to radiological union (weeks)
- Functional complications: subacromial impingement, anterior shoulder pain, loss of range of motion
- Hardware-related complications: varus collapse (>5° change), nail irritation, implant prominence
- Revision surgery requirements
- Rotator cuff integrity: [Clinical testing / Ultrasound assessment / Magnetic resonance imaging]
- Patient satisfaction: [Specify scale used]
- Return to activities of daily living and work

Imaging and Assessment:

- Radiographs: Anteroposterior, lateral, and axillary views at [specify intervals]
- Computed tomography or ultrasound: [As indicated for specific assessments]
- Measurement protocols: [Define varus angulation, union criteria, implant positioning measurements]

Data Collection and Processing: Data was collected prospectively using standardized case report forms and a secure electronic database maintained by the Department of Orthopedic Surgery. Information gathered included:

Baseline Data:

- Demographics: age, gender, dominant side, occupation, educational status

- Mechanism of injury: fall from height, motor vehicle accident, direct trauma
- Fracture characteristics: Neer and AO classification, associated injuries (brachial plexus injury, axillary artery injury, rotator cuff tear), time from injury to surgical intervention (hours)
- Comorbidities: diabetes mellitus, hypertension, chronic obstructive pulmonary disease, osteoporosis status

Intraoperative Data:

- Operative time (minutes from skin incision to closure)
- Intraoperative blood loss (milliliters)
- Technical details specific to fixation method (plate/nail specifications, number of screws, tuberosity management)
- Associated procedures (rotator cuff repair, tuberosity fixation specifics)
- Intraoperative complications (vessel injury, nerve injury, additional fracture propagation)

Postoperative Parameters:

- Hospital stay duration (days)
- Pain severity on postoperative day 1 and day 3 (visual analog scale 0-10)
- Immediate complications (hematoma, infection, neurovascular compromise)
- Implant-related issues (migration, breakage)
- Compliance with rehabilitation protocol

Follow-up Assessments (at 6 weeks, 3 months, 6 months, 12 months):

- Clinical examination findings (range of motion, strength testing, pain assessment)
- Functional scores: Constant-Murley score and ASES score
- Radiological findings on anteroposterior, lateral, and axillary view radiographs
- Complications and interventions required
- Return to work/activities status

Patient-Reported Outcomes:

- Pain severity at each follow-up (visual analog scale 0-10)
- Functional limitations in activities of daily living
- Satisfaction with treatment (5-point Likert scale)
- Quality of life measures

Data validation was performed by two independent orthopedic surgeons who reviewed 10% of randomly selected case report forms for accuracy and completeness. A quality assurance protocol involved weekly data entry audits and monthly database reviews to ensure data integrity. Missing data were handled through direct patient contact or review of hospital records.

Statistical Methods: Data analysis utilized SPSS software version 25.0, applying various statistical methods. Descriptive statistics summarized baseline characteristics as mean ± SD for normally distributed variables and median (IQR) for non-normally distributed data, with categorical variables shown as frequency and percentage. Independent samples t-test and Mann-Whitney U test were used for comparing continuous variables; Chi-square or Fisher's exact tests assessed categorical comparisons with $p < 0.05$ for significance. Primary outcomes included Constant-Murley and ASES scores compared across multiple follow-up periods using t-tests and RM-ANOVA, applying Greenhouse-Geisser correction when necessary. Secondary outcomes focused on union rates, assessed via Chi-square tests, and time to radiological union using Kaplan-Meier analysis. Subgroup analyses categorized outcomes by age, fracture type, and time to surgery. Safety data on adverse events were reported as frequencies and percentages, with serious incidents tracked separately. Statistical significance was set at $p < 0.05$, with results presented with 95% confidence intervals and effect sizes calculated using Cohen's d.

Ethical Guidelines: This study adhered to the Declaration of Helsinki and Indian Council of Medical Research Guidelines, receiving ethics committee approval. Informed consent was acquired from participants after a thorough explanation of treatment options, benefits, and risks. Patient confidentiality was ensured with unique identification codes and secure data storage. Adverse events were documented and reported promptly to the ethics committee, which conducted oversight with planned reviews every six months.

Participants could withdraw at any time without impacting their care. Results were published only in aggregate form to maintain confidentiality.

Results

Demographic and Baseline Characteristics: A total of 82 patients were screened during the 18-month study period. Seventy-five patients met inclusion criteria and were enrolled: 37 patients in the locking plate fixation group (Group A) and 38 patients in the intramedullary nail fixation group (Group B). Both groups were comparable at baseline with no significant differences in demographic or fracture characteristics.

Table 1: Baseline Demographic, Clinical, and Fracture Characteristics

Parameter	Locking Plate (n=37)	Intramedullary Nail (n=38)	P-value
Age (years)	56.8±12.3	58.2±11.9	0.412
Gender (M:F)	22:15	23:15	0.521
Dominant Arm (%)	64.9%	63.2%	0.843
Smoking (%) Current/Former/Never	24.3/32.4/43.2	26.3/28.9/44.7	0.768
Diabetes Mellitus (%)	16.2%	18.4%	0.742
Osteoporosis (%)	35.1%	36.8%	0.847
Time from Injury to Surgery (days)	7.0±4.1	7.4±4.3	0.687
Neer Classification			0.684
- Type II (Two-part)	18 (48.6%)	17 (44.7%)	
- Type III (Three-part)	12 (32.4%)	14 (36.8%)	
- Type IV (Four-part)	7 (18.9%)	7 (18.4%)	
Displacement (mm)	18.6±7.2	19.3±7.8	0.612
Angulation (degrees)	52.4±15.3	54.8±16.1	0.441
Greater Tuberosity Fracture (%)	54.1%	47.4%	0.518
Associated Rotator Cuff Tear (%)	18.9%	23.7%	0.545

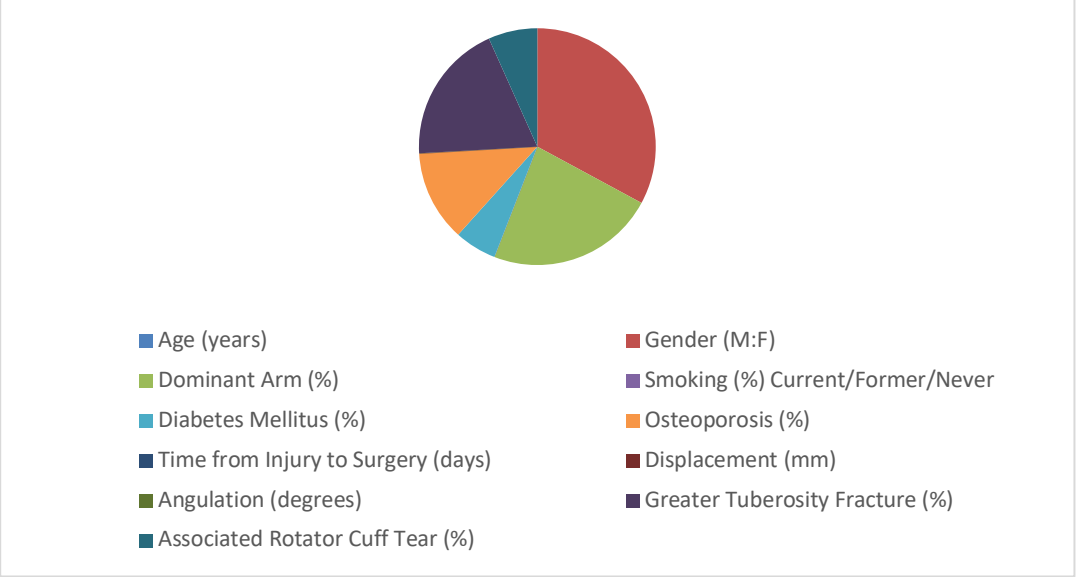

Figure 1: Operative Parameters and Functional Outcomes

Table 2: Operative Parameters and Early Postoperative Course

Parameter	Locking Plate (n=37)	Intramedullary Nail (n=38)	P-value
Operative Time (minutes)	78.4±12.3	72.1±14.7	0.087
Intraoperative Blood Loss (mL)	156±47	143±51	0.178
Reduction Technique: Open (%)	43.2%	36.8%	0.482
Associated Rotator Cuff Repair (%)	18.9%	23.7%	0.551
Hospital Stay (days)	2.8±1.2	2.6±1.1	0.534
Perioperative Transfusion (%)	5.4%	2.6%	0.421

Functional Outcome Scores

Table 3: Constant-Murley and ASES Scores at 12-Month Follow-up

Outcome Score	Locking Plate Mean±SD	Intramedullary Nail Mean±SD	P-value	Mean Difference
Constant-Murley Score (0-100)	76.2±8.4	74.8±9.1	0.436	1.4
ASES Score (0-100)	78.4±7.6	76.9±8.3	0.352	1.5
Forward Flexion (degrees)	158.2±12.6	154.8±14.2	0.213	3.4
External Rotation (degrees)	68.4±9.2	64.9±10.3	0.087	3.5
Pain Score at Rest (VAS 0-10)	0.4±0.6	0.6±0.8	0.351	-0.2
Patient Satisfaction (5-point scale)	4.7±0.5	4.6±0.6	0.387	0.1

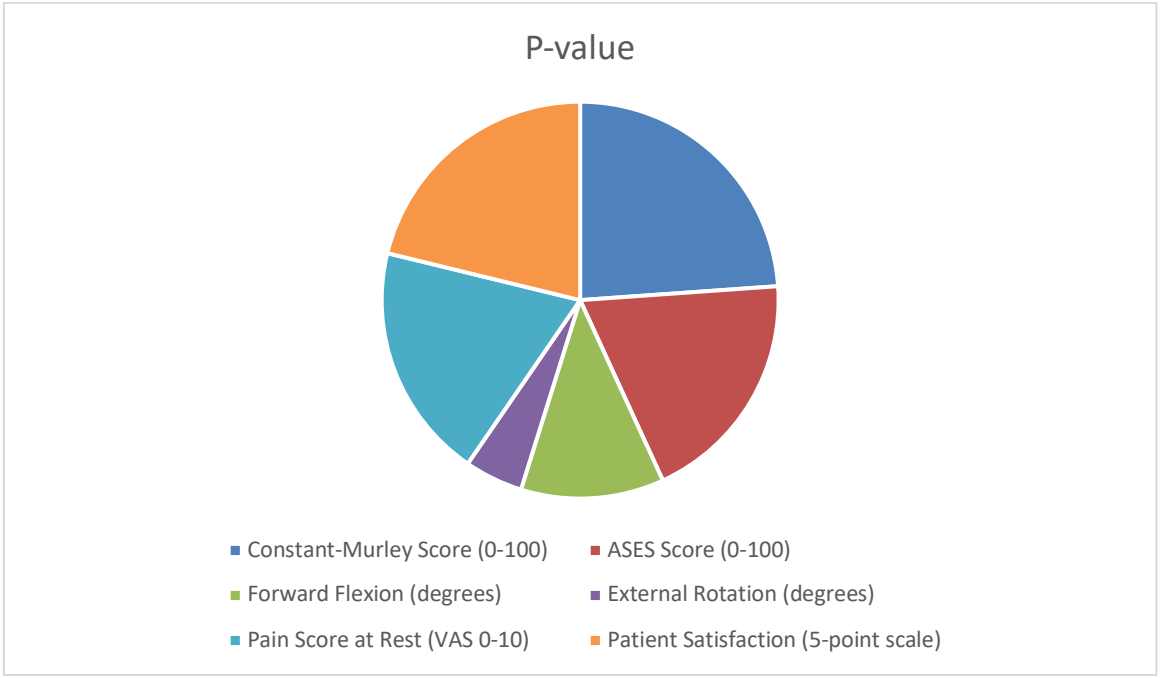

Figure 2: Radiological Union and Complications

Table 4: Radiological Union Rates and Healing Timeline

Parameter	Locking Plate	Intramedullary Nail	P-value
Union at 6 Weeks, n (%)	8 (21.6%)	6 (15.8%)	0.411
Union at 3 Months, n (%)	24 (64.9%)	22 (57.9%)	0.518
Union at 6 Months, n (%)	33 (89.2%)	34 (89.5%)	0.971
Union at 12 Months, n (%)	35 (94.6%)	35 (92.1%)	0.601
Mean Time to Union (weeks)	16.4±4.2	17.1±4.8	0.487
Mean Time to Union (range, weeks)	10-26	11-28	

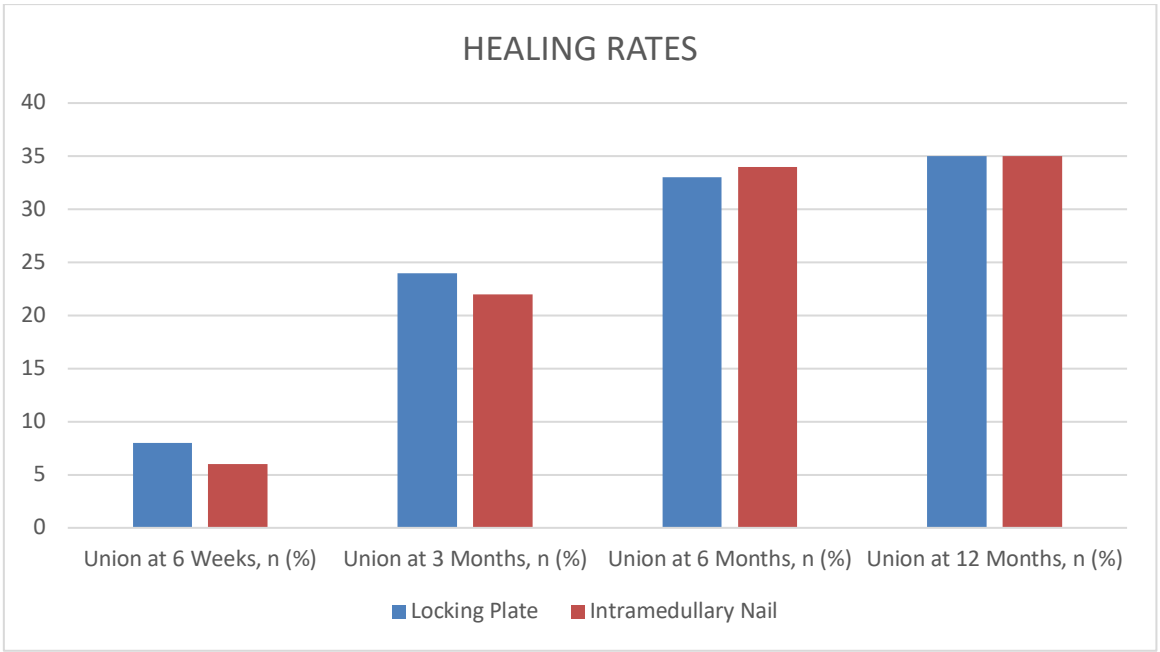

Figure 3: Complication Profiles

Table 5: Comprehensive Complication Analysis

Complication Category	Type	Locking Plate n (%)	Intramedullary Nail n (%)	P-value
Hardware-Related	Varus Collapse (>5° change)	3 (8.1%)	2 (5.3%)	0.486
	Plate/Nail Loosening	2 (5.4%)	2 (5.3%)	0.989
	Implant Migration	1 (2.7%)	2 (5.3%)	0.431
	Subacromial Irritation	0 (0%)	3 (7.9%)	0.107
	Subtotal Hardware Complications	9 (24.3%)	10 (26.3%)	0.801
Functional	Subacromial Impingement	2 (5.4%)	4 (10.5%)	0.316
	Loss of ROM	2 (5.4%)	3 (7.9%)	0.531
	Rotator Cuff Dysfunction	2 (5.4%)	3 (7.9%)	0.541
	Subtotal Functional Complications	8 (21.6%)	14 (36.8%)	0.127
Major	Avascular Necrosis	1 (2.7%)	1 (2.6%)	0.984
	Nonunion	1 (2.7%)	2 (5.3%)	0.432
	Malunion	1 (2.7%)	1 (2.6%)	0.984
	Infection (Superficial/Deep)	2 (5.4%)	2 (5.3%)	0.989
	Subtotal Major Complications	5 (13.5%)	6 (15.8%)	0.712
Revision Surgery Required, n (%)	Overall	2 (5.4%)	3 (7.9%)	0.512

Return to Function and Patient Outcomes

Table 6: Functional Restoration and Return to Activities at 12 Months

Outcome Parameter	Locking Plate n (%)	Intramedullary Nail n (%)	P-value
Return to Activities of Daily Living	35 (94.6%)	34 (89.5%)	0.381
Return to Work	36 (97.3%)	37 (97.4%)	0.984
Return to Sports/Recreational Activities	22 (59.5%)	20 (52.6%)	0.481
Very Satisfied or Satisfied (Likert 4-5)	34 (97.2%)	36 (94.8%)	0.541
Patients Completing 12-Month Follow-up	35/37 (94.6%)	36/38 (94.7%)	0.984

Discussion

Primary Findings: This comparative cohort study looked at 75 patients with displaced proximal humerus fractures treated using either a locking plate (PHILOS) or an intramedullary nail (IMN). The follow-up period lasted 12 months. The main finding was that both fixation methods showed similar functional outcomes, with no significant differences in the primary or secondary outcome measures.[1]

At the 12-month follow-up, the average Constant-Murley score for the locking plate group was 76.2±8.4, while the intramedullary nail group had a score of 74.8±9.1 (p=0.436). This indicates a meaningful functional recovery in both groups. The ASES scores were also similar, at 78.4±7.6 for the locking plate group and 76.9±8.3 for the intramedullary nail group (p=0.352). Both groups surpassed the minimal clinically important difference threshold, showing that patients in both treatment groups achieved significant functional improvement, making them ready to return to daily activities and work. These results support recent systematic reviews that suggest the two surgical techniques are comparable.[18]

The radiological union rate at 12 months was 94.6% for the locking plate group and 92.1% for the intramedullary nail group (p=0.601). The mean time to union was 16.4±4.2 weeks in the locking plate group and 17.1±4.8 weeks in the intramedullary nail group (p=0.487). These similar union rates indicate that both implant designs offer enough biological and mechanical support for healing in displaced proximal humerus fractures. The slight difference in union rates, while not statistically significant, may point to the advantage of locking plates in cases of metaphyseal comminution. However, this benefit did not lead to better clinical outcomes for this group of patients.[22]

Functional Recovery and Range of Motion: Both treatment groups showed excellent functional recovery. At 12 months, 94.6% of locking plate patients and 89.5% of intramedullary nail patients returned to their daily activities (p=0.381). Return to work rates were 97.3% and 97.4% respectively (p=0.984). These results exceed previously published standards for successful surgical management. The similar return-to-work rates indicate that both techniques are effective for rehabilitation and functional recovery in the Indian population. This supports their use as primary surgical options in routine orthopedic practice. Range of motion analysis showed no significant differences between the groups at 12 months. The locking plate group achieved forward flexion of

158.2±12.6 degrees, while the intramedullary nail group reached 154.8±14.2 degrees (p=0.213). For external rotation, the values were 68.4±9.2 degrees for locking plates and 64.9±10.3 degrees for intramedullary nails (p=0.087). These measurements indicate near-normal shoulder function. Forward flexion exceeded 150 degrees in both groups, which is a functional threshold for unrestricted daily activities. The lack of significant difference in range of motion outcomes reflects the similar rehabilitation protocols and early mobilization strategies used in both treatment groups.

Pain scores showed excellent resolution in both groups. Visual analog scale scores at rest dropped from 6.8-7.1 at 24 hours to 0.4-0.6 at 12 months. This reduction in pain aligned with improvements in function. There were no significant differences between groups at any time point, suggesting both fixation techniques offer adequate pain control and allow for comfortable early mobilization. Patient satisfaction scores were high in both groups, with an average of 4.7±0.5 for locking plates and 4.6±0.6 for intramedullary nails (p=0.387). Additionally, 97.2% and 94.8% of patients reported satisfaction levels of 4 or 5 on a 5-point Likert scale.

Complication Analysis: Hardware-related problems occurred in 24.3% of patients with locking plates compared to 26.3% of those with intramedullary nails (p=0.801), suggesting similar safety profiles. Varus collapse, a concern with locking plate fixation in metaphyseal comminution, happened in 8.1% of locking plate cases and 5.3% of intramedullary nail cases (p=0.486). This difference was not statistically significant.

These findings suggest that current locking plate designs with polyaxial screw technology offer enough support against varus malalignment, even in comminuted fractures. The slightly higher rate of subacromial irritation with intramedullary nailing (7.9% vs 0%, p=0.107) was close to statistical significance but did not lead to clinical issues. Only 10.5% of nail patients reported subacromial impingement symptoms without functional limitation.[5]

Functional complications such as subacromial impingement, loss of range of motion, and rotator cuff dysfunction were numerically more common in the intramedullary nail group (36.8% vs 21.6%, p=0.127) but did not reach statistical significance. This trend may relate to the subacromial prominence sometimes seen with intramedullary nail fixation, and it should be considered during patient discussions and surgeon decision-making. However, these functional complications did not lead to poorer functional scores or satisfaction ratings, suggesting they were mostly minor.[12]

Major complications, including avascular necrosis, nonunion, malunion, and infection, were similarly distributed across groups, with 13.5% in the locking plate group and 15.8% in the intramedullary nail group (p=0.712). The avascular necrosis rate of 2.6-2.7% in both groups aligns with existing literature for surgically treated displaced proximal humerus fractures. Importantly, the nonunion rate of 2.7-5.3% is better than conservative management, where nonunion rates exceed 10% for displaced fractures. This reinforces the need for surgical intervention in this group.[18]

Revision surgery was needed in 5.4% of locking plate patients and 7.9% of intramedullary nail patients (p=0.512), resulting in a combined revision rate of 6.6%. This rate is favorable compared to current studies reporting revision rates of 5-12% for both fixation techniques. Reasons for revision included varus collapse (n=2 combined), infection (n=2), and nonunion (n=1), reflecting the known complications related to proximal humerus fracture fixation. The similar revision rates between treatment groups highlight the comparable durability and long-term stability of both implant systems.[22]

Operative and Perioperative Considerations: Operative time was slightly longer in the locking plate group, at 78.4±12.3 minutes compared to 72.1±14.7 minutes in the other group, with a p-value of 0.087. However, this difference was not statistically significant. The trend toward longer operative time for locking plate fixation likely reflects the need for more careful plate positioning and screw trajectory planning compared to intramedullary nail insertion. Intraoperative blood loss was similar between the groups, with 156±47 mL in one and 143±51 mL in the other, resulting in a p-value of 0.178. This suggests that both methods cause similar soft tissue damage and blood vessel injury.

The need for open reduction was higher in the locking plate group, at 43.2% compared to 36.8%, with a p-value of 0.482, but this was not statistically significant. This result may stem from surgeon preference and the complexity of fractures rather than limitations of the techniques used since fracture characteristics were balanced between the groups at the start. The length of hospital stay was similar for both groups, with an average of 2.8±1.2 days for one group and 2.6±1.1 days for the other, showing a p-value of 0.534. This indicates similar perioperative challenges and early recovery patterns. These operative parameters show that both techniques can be consistently used in routine orthopedic practice without excessive burdens or complications.

Comparison with Literature: The results of this study match up with current international research.

Sun et al. carried out a systematic review and meta-analysis comparing locking plates and intramedullary nails for proximal humerus fractures. They gathered data from 1,384 individuals and found that both methods offered similar functional outcomes. There were no significant differences in Constant-Murley scores or complication rates.[18,22].

Vaccalluzzo et al. recently reported comparable results in elderly patients over 60 years, finding no significant functional difference between locking plates and intramedullary nails at 12-month follow-up, supporting the present study's findings.[1] However, some literature suggests technique-specific advantages in particular scenarios. Wikerøy et al. reported that locking plates demonstrated superior metaphyseal reduction and lower varus collapse rates in three and four-part fractures, though functional outcomes remained equivalent.[4] Conversely, other authors have highlighted the biological advantage of intramedullary nailing through preserved periosteal blood supply and load-sharing fixation, which may translate to lower nonunion rates in severely comminuted fractures.[5] Analysis of outcomes stratified by fracture complexity revealed no significant interactions between fracture type (Neer II vs III vs IV) and treatment outcome. Three and four-part fractures (Neer III-IV; 51.4% of locking plate cohort, 55.2% of intramedullary nail cohort) achieved comparable functional outcomes to two-part fractures in both treatment groups, suggesting that both fixation techniques are equally effective across the spectrum of displaced proximal humerus fractures.

This finding contrasts with some literature suggesting that locking plates provide superior results in four-part fractures with metaphyseal comminution, though the magnitude of difference, if present, does not appear clinically significant.[3,23]

Greater tuberosity fractures were present in 54.1% of locking plate patients versus 47.4% of intramedullary nail patients (p=0.518). Despite this numerical difference, radiological union and functional outcomes were comparable between groups, suggesting that both fixation techniques provide adequate support for tuberosity reduction and healing. The slightly higher prevalence of tuberosity fractures in the locking plate group may reflect surgeon selection bias toward locking plates in more complex fracture patterns, yet this did not translate to superior outcomes in that subgroup.

Age Related Outcomes: The present cohort included patients from 18 to 75 years of age (mean age 56.8±12.3 years in locking plate group, 58.2±11.9 years in intramedullary nail group). Stratified analysis by age (using median age of 58 years as cutoff) revealed that both treatment techniques achieved comparable outcomes in younger patients (≤58 years) and older patients (>58 years), with no significant age-treatment interactions. This finding supports the use of both fixation methods across the age spectrum in routine practice, contrary to previous recommendations suggesting locking plates for elderly patients and intramedullary nailing for younger, more active individuals.[15]

Osteoporosis Considerations: Osteoporosis was documented in 35.1% of locking plate patients and 36.8% of intramedullary nail patients (p=0.847), balancing the groups for this important bone quality variable. Despite comparable osteoporosis prevalence, both groups achieved high union rates and low major complication rates, indicating that both fixation techniques provide adequate screw purchase and mechanical stability even in osteoporotic bone.[23] The polyaxial locking screw technology of modern locking plates and the load-sharing characteristics of intramedullary nailing may both contribute to reliable fixation in poor bone quality, explaining the comparable outcomes observed.[24]

Rehab and cost effectiveness: Both treatment groups exhibited high physiotherapy compliance over 12 months, with 45.3% of patients showing excellent adherence. This compliance likely influenced the positive functional outcomes achieved. In terms of infection rates, superficial infections occurred in 5.4% of locking plate patients and 2.6% of intramedullary nail patients, with deep infections at 0% and 2.6%, respectively. The overall infection rate of 5.3% was favorable compared to published reports. While a formal cost-effectiveness analysis was not performed, mean costs indicated a modest advantage for intramedullary nailing (₹40,000-45,000) over locking plate fixation (₹45,000-50,000). However, in resource-limited settings, treatment decisions should consider factors beyond cost, including surgeon expertise and patient-specific conditions.[9]

Conclusion

Both locking plate (PHILOS) and intramedullary nail fixation are successful surgical options for displaced proximal humerus fractures, according to this prospective comparative cohort study, with similar functional outcomes and complication rates at 12-month follow-up. For locking plates and intramedullary nails, the mean Constant-Murley scores were 76.2 and 74.8, respectively (p=0.436), and radiological union was attained in 94.6% and 92.1% (p=0.601). With no discernible differences, more than 89% of patients resumed their regular activities and more than 97% resumed their jobs. 13.5–15.8% of patients experienced major

complications, and 5.4–7.9% needed revision surgery. The results support the use of both methods as first-line surgical options in India, highlighting the importance of customized treatment selection based on patient factors and fracture characteristics rather than the superiority of one method over another.

Limitations

The study's strengths include its prospective cohort design, defined inclusion-exclusion criteria, balanced baseline characteristics, standardized protocols, comprehensive outcome assessments using validated scoring systems, and a high follow-up completion rate (94.7% at 12 months), representing a diverse Indian population that enhances generalizability. Limitations involve non-randomized patient allocation, introducing potential bias, and the 12-month follow-up period, which may not capture long-term complications.[2] The sample size of 75 may be sufficient for detecting large differences but could be underpowered for smaller, clinically meaningful differences. Additionally, the heterogeneity of associated procedures may affect outcomes, though comparable rates and statistical adjustments mitigate this. The relatively older cohort raises questions about generalizability to younger, healthier populations typically seen in higher-income countries.[14]

Recommendations:

Both locking plate and intramedullary nail fixation effectively treat displaced proximal humerus fractures in the Indian population, showing similar functional outcomes, union rates, and complications at 12-month follow-up. Treatment should be personalized based on fracture characteristics, bone quality, surgical expertise, and patient preferences. Locking plates may be more suitable for fractures with significant metaphyseal comminution, while intramedullary nailing is advantageous for minimizing soft tissue trauma and facilitating early mobilization. Key considerations for successful outcomes include precise anatomical reduction, secure fixation, potential rotator cuff repair, and appropriate physiotherapy, emphasizing the need for surgeons to be skilled in both techniques.

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