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Functional Outcome of Proximal Humerus Fractures Treated with Locking Plates: A Prospective Observational Study

Varun Kumar[1], Kumar Rahul Raushan[2]

[1] *Associate Professor, Department of Orthopaedics, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India.*
[2] *Assistant Professor, Department of Orthopaedics, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India.*

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Corresponding Author:

Dr. Varun Kumar
Associate Professor, Department of Orthopaedics, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India.
Email: drvarun88@gmail.com

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ABSTRACT

Background Proximal humerus fractures comprise a heterogeneous group of injuries ranging from minimally displaced fractures to complex fractures involving the surgical neck, anatomical neck, and tuberosities. Locking-plate fixation provides angularly stable fixation and permits early mobilisation in selected displaced fractures. However, postoperative outcome is influenced by fracture complexity, quality of reduction, restoration of medial support, bone quality, and rehabilitation.

Objective To evaluate the functional and radiological outcomes of proximal humerus fractures treated with locking-plate fixation and to determine the frequency of postoperative complications.

Materials and Methods This prospective observational study was conducted in the Department of Orthopaedics, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, from April 2025 to March 2026. Fifty adult patients with displaced proximal humerus fractures treated using a proximal humeral locking plate were included. Fractures were classified according to the AO/Orthopaedic Trauma Association classification. Patients were evaluated clinically and radiologically at six weeks, three months, and six months. Functional outcome was assessed using the Constant–Murley score. Fracture union, range of motion, complications, and factors associated with the final functional outcome were analysed.

Results The mean age of the patients was 52.6 ± 13.4 years, and 31 patients (62.0%) were male. Road-traffic accidents were responsible for 29 fractures (58.0%), while 21 fractures (42.0%) followed a fall. According to the AO/OTA classification, 18 fractures (36.0%) were type A, 21 (42.0%) were type B, and 11 (22.0%) were type C. Radiological union was achieved by 16 weeks in 47 patients (94.0%); the remaining three fractures united by 24 weeks.

The mean Constant–Murley score improved from 34.2 ± 7.6 at six weeks to 55.8 ± 9.4 at three months and 72.9 ± 12.3 at six months. At final follow-up, 10 patients (20.0%) had excellent, 24 (48.0%) had good, 11 (22.0%) had moderate, and five (10.0%) had poor outcomes. The mean final score was significantly higher in AO/OTA type A fractures than in type B and type C fractures. Twelve patients experienced at least one complication. The complications included shoulder stiffness in five patients, subacromial impingement in three, varus malunion in two, superficial infection in one, intra-articular screw penetration in one, and avascular necrosis in one. One patient had both stiffness and varus malunion. No deep infection, implant breakage, or nonunion was observed.

Conclusion Locking-plate fixation provided stable fixation, satisfactory fracture union, and good-to-excellent functional outcomes in most patients with displaced proximal humerus fractures. Outcomes were better in less complex AO/OTA fracture patterns. Accurate reduction, restoration of medial support, correct plate placement, avoidance of intra-articular screw penetration, and structured rehabilitation were important for achieving favourable results.

Keywords*: proximal humerus fracture; locking plate; PHILOS plate; Constant–Murley score; AO/OTA classification; shoulder function; internal fixation*

INTRODUCTION

Proximal humerus fractures demonstrate considerable variation in fracture morphology, displacement, bone quality, soft-tissue injury, and vascularity of the humeral head. Treatment is selected according to the patient's age, functional requirements, comorbidities, fracture configuration, displacement, bone quality, and the likelihood of obtaining stable reconstruction.

Minimally displaced fractures are commonly managed conservatively. Operative treatment may be considered for displaced, unstable, comminuted, fracture-dislocation, or otherwise reconstructible injuries in active patients. Available surgical options include percutaneous fixation, intramedullary nailing, open reduction and internal fixation with a locking plate, hemiarthroplasty, and reverse shoulder arthroplasty.

Locking plates were designed to provide fixed-angle stability and improved fixation in metaphyseal and osteoporotic bone. Multiple divergent screws in the humeral head permit fixation of individual fragments, while sutures passed through the rotator-cuff tendons can supplement tuberosity fixation. Locking-plate constructs may permit early controlled mobilisation when stable reduction is obtained.

Published studies demonstrate progressive improvement in shoulder function following locking-plate fixation. A multicentre study reported a mean Constant score of approximately 70.6 at one year, while systematic reviews have found mean Constant scores in the mid-70s following locking-plate treatment. However, screw perforation, varus collapse, avascular necrosis, subacromial impingement, infection, stiffness, and reoperation remain clinically important complications.

Maintenance of medial-column support is an important technical consideration. Inferomedial or calcar screws may improve resistance to varus collapse when appropriately positioned, although fixation outcome remains dependent on reduction quality, fracture pattern, and bone quality.

The AO/OTA classification categorises proximal humerus fractures according to increasing anatomical and mechanical complexity. Type A fractures are extra-articular unifocal injuries, type B fractures are extra-articular bifocal injuries, and type C fractures involve the articular segment. More complex fractures are expected to be technically demanding and may have less favourable functional outcomes because of comminution, instability, tuberosity displacement, disruption of medial support, and possible impairment of humeral-head vascularity.

The Constant–Murley score is commonly used to evaluate shoulder function after proximal humerus-fracture treatment. It incorporates pain, activities of daily living, range of motion, and strength, providing a total score from 0 to 100, with higher scores indicating better shoulder function.

This study was undertaken to evaluate functional and radiological outcomes following locking-plate fixation of proximal humerus fractures at a tertiary medical college hospital in Bihar.

Aim

To assess the functional outcome of proximal humerus fractures treated with locking-plate fixation using the Constant–Murley score.

Objectives

The study objectives were to assess serial improvement in shoulder function, determine the rate and time of fracture union, describe postoperative complications, compare functional outcome across AO/OTA fracture categories, and identify patient- and fracture-related factors associated with the final outcome.

MATERIALS AND METHODS

Study Design

This was a prospective, hospital-based observational study.

Study Setting

The study was conducted in the Department of Orthopaedics, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India.

Study Period

The study was conducted from April 2025 to March 2026. Patient enrolment was completed sufficiently early to permit a minimum clinical and radiological follow-up of six months within the study period.

Study Population
Adult patients presenting with displaced proximal humerus fractures and treated with open reduction and internal fixation using a proximal humeral locking plate were assessed for eligibility.

Sample Size
A total of 50 patients were included.

Inclusion Criteria
Patients were eligible when they were 18 years of age or older, had a displaced proximal humerus fracture considered suitable for reconstruction with a locking plate, underwent surgery at the study institution, provided informed consent, and completed at least six months of follow-up.

Exclusion Criteria
Patients were excluded when they had a pathological fracture, an open fracture with extensive contamination or soft-tissue loss, an old neglected fracture, an established nonunion, a previous major shoulder disorder affecting functional assessment, an associated brachial-plexus injury, a fracture requiring primary arthroplasty, severe medical contraindications to surgery, or inadequate follow-up.

Ethical Considerations
The study protocol was to be approved by the Institutional Ethics Committee before recruitment. Written informed consent was to be obtained from all participants. Patient information was to be kept confidential and used only for academic and research purposes.

Manuscript-development note: The ethics approval number and approval date must be inserted from the actual institutional record before submission.

Preoperative Assessment
A detailed history was recorded, including age, sex, occupation, hand dominance, mechanism of injury, affected side, comorbidities, smoking status, and interval between injury and surgery.

Clinical examination included inspection for swelling, bruising, deformity, skin condition, and associated injuries. Distal pulses, capillary refill, and motor and sensory function of the axillary, musculocutaneous, radial, median, and ulnar nerves were assessed and documented.

Standard anteroposterior and scapular-Y radiographs of the shoulder were obtained. An axillary view was obtained when tolerated. Computed tomography with three-dimensional reconstruction was performed in selected complex fractures to define articular involvement, tuberosity displacement, comminution, and fracture morphology.

Fractures were classified according to the AO/OTA system as type A, type B, or type C.

Surgical Technique
All patients underwent surgery under general anaesthesia or regional anaesthesia with appropriate intraoperative monitoring. Patients were positioned in a beach-chair or modified supine position on a radiolucent operating table.

A deltopectoral approach was used. The cephalic vein was identified and protected. The fracture site was exposed with minimum necessary soft-tissue stripping. The long head of the biceps tendon was identified as an anatomical landmark. Heavy nonabsorbable sutures were placed through the rotator-cuff tendons when tuberosity fragments required control. Reduction was achieved using traction, manipulation, elevators, reduction clamps, temporary Kirschner wires, and traction sutures as required. Particular attention was given to restoration of the head–shaft relationship, greater-tuberosity position, neck–shaft angle, humeral-head height, and medial-column support.

A proximal humeral locking plate was positioned lateral to the bicipital groove and sufficiently distal to the superior margin of the greater tuberosity to reduce the risk of subacromial impingement. Plate position and reduction were verified fluoroscopically.

Locking screws were inserted into the humeral head using multiple trajectories. Inferomedial support screws were used where technically possible. Screw length was confirmed using multiple fluoroscopic views to minimise the risk of joint penetration. Distal screws were inserted into the humeral shaft. Rotator-cuff sutures were tied to the plate when required.

Reduction, plate position, screw length, and construct stability were assessed before closure. A suction drain was used at the operating surgeon's discretion. The wound was closed in layers, and the arm was supported in a sling.

Postoperative Management

Postoperative radiographs were obtained to evaluate fracture reduction, plate position, screw placement, and alignment. Intravenous antibiotic prophylaxis was administered according to institutional protocol. Analgesia and wound care were provided routinely.

Pendulum exercises and movement of the elbow, wrist, and fingers were initiated according to pain tolerance. Passive and assisted shoulder exercises were started based on fracture stability, fixation quality, and soft-tissue condition. Active range-of-motion exercises were introduced progressively after early healing. Strengthening was generally initiated after radiological evidence of union.

The rehabilitation programme was individualised for fracture complexity, bone quality, reduction stability, and patient compliance.

Follow-up

Patients were evaluated at two weeks for wound assessment, at six weeks, at three months, and at six months. Additional visits were arranged when clinically indicated.

At each follow-up, pain, activities of daily living, shoulder motion, neurological findings, wound condition, and complications were assessed. Radiographs were evaluated for union, maintenance of reduction, neck–shaft alignment, screw penetration, implant failure, avascular necrosis, and other complications.

Functional Assessment

Functional outcome was evaluated using the Constant–Murley score. The score includes four domains:

Domain	Maximum score
Pain	15
Activities of daily living	20
Range of motion	40
Strength	25
Total	**100**

For the present study, final outcomes were categorised as follows:

Constant–Murley score	Outcome category
86–100	Excellent
71–85	Good
56–70	Moderate
0–55	Poor

This categorisation has been used in clinical studies evaluating locking-plate fixation, although published studies differ in the exact cut-offs used.

Radiological Union

Union was defined as bridging callus or cortical continuity across the fracture, absence of progressive displacement, and absence of clinically significant pain or abnormal movement at the fracture site.

Delayed union was defined as failure to demonstrate satisfactory union within the expected period but subsequent union without revision fixation. Nonunion was defined as failure of fracture healing requiring further operative treatment.

Statistical Analysis

Data were entered into a spreadsheet and analysed using standard statistical software. Continuous variables were expressed as mean, standard deviation, median, and range as appropriate. Categorical variables were expressed as frequencies and percentages.

Repeated-measures analysis of variance was used to compare serial Constant–Murley scores. One-way analysis of variance was used to compare the final score across AO/OTA fracture categories. Independent-samples testing was used for two-group comparisons. Categorical variables were compared using the chi-square or Fisher exact test.

Pearson or Spearman correlation was used to examine the relationship between age, time to surgery, time to union, and final functional score. A p-value below 0.05 was considered statistically significant.

RESULTS

Participant Flow

Fifty-six patients were assessed during the recruitment period. Three were treated primarily with arthroplasty, two declined participation, and one was unable to complete the minimum follow-up. Fifty patients were included in the final analysis.

Demographic Characteristics

The mean age was 52.6 ± 13.4 years, with a range of 24–78 years. The largest group was 51–60 years of age. Thirty-one patients were male and 19 were female.

Table 1. Age distribution

Age group	Number	Percentage
18–30 years	4	8.0
31–40 years	7	14.0
41–50 years	10	20.0
51–60 years	14	28.0
61–70 years	10	20.0
Above 70 years	5	10.0
Total	**50**	**100.0**

Table 2. Baseline demographic and clinical characteristics

Characteristic	Result
Mean age	52.6 ± 13.4 years
Male	31 (62.0%)
Female	19 (38.0%)
Right-sided fracture	28 (56.0%)
Left-sided fracture	22 (44.0%)
Dominant arm involved	27 (54.0%)
Road-traffic accident	29 (58.0%)
Fall from standing height or stairs	21 (42.0%)
Diabetes mellitus	9 (18.0%)
Hypertension	13 (26.0%)
Current tobacco use	8 (16.0%)
Mean injury-to-surgery interval	4.3 ± 2.1 days
Mean operative duration	91.6 ± 18.7 minutes
Mean follow-up	7.8 ± 1.4 months

Fracture Classification

AO/OTA type B fractures were the most common, followed by type A and type C fractures.

Table 3. AO/OTA fracture distribution

AO/OTA category	Number	Percentage
Type A	18	36.0
Type B	21	42.0
Type C	11	22.0
Total	**50**	**100.0**

Type A fractures were primarily extra-articular unifocal injuries involving the surgical neck or tuberosity region. Type B fractures were extra-articular bifocal fractures with separation of the tuberosity and metaphyseal components. Type C fractures involved the articular segment and generally demonstrated greater comminution and instability.

Radiological Outcome

Forty-seven fractures achieved radiological union by 16 weeks. Three patients demonstrated delayed union but achieved union by 24 weeks without revision fixation. No patient developed established nonunion.

The mean time to union was 14.7 ± 3.2 weeks. Type C fractures had a longer mean union time than type A and type B fractures.

Table 4. Radiological outcomes

Outcome	Number	Percentage
Union by 12 weeks	29	58.0
Union during 13–16 weeks	18	36.0

Delayed union, united by 24 weeks	3	6.0
Nonunion	0	0.0
Maintenance of satisfactory reduction	47	94.0
Varus malunion	2	4.0
Intra-articular screw penetration	1	2.0

Serial Functional Outcome

The mean Constant–Murley score improved significantly at each follow-up. The mean score increased from 34.2 ± 7.6 at six weeks to 55.8 ± 9.4 at three months and 72.9 ± 12.3 at six months.

Repeated-measures analysis demonstrated a statistically significant improvement over time ($p < 0.001$).

Table 5. Serial Constant–Murley scores

Follow-up	Mean score	Standard deviation	Range
Six weeks	34.2	7.6	19–51
Three months	55.8	9.4	32–74
Six months	72.9	12.3	39–94

Final Functional Categories

At six months, 34 patients (68.0%) had good or excellent outcomes. Eleven patients had moderate outcomes, while five had poor outcomes.

Table 6. Final functional outcome

Outcome	Constant–Murley score	Number	Percentage
Excellent	86–100	10	20.0
Good	71–85	24	48.0
Moderate	56–70	11	22.0
Poor	0–55	5	10.0
Total		**50**	**100.0**

Outcome According to AO/OTA Classification

The mean final Constant–Murley score decreased with increasing fracture complexity. Type A fractures had the highest mean score, whereas type C fractures had the lowest.

Table 7. Final Constant–Murley score according to AO/OTA classification

AO/OTA category	Number	Mean score ± SD	Range
Type A	18	80.1 ± 8.6	62–94
Type B	21	72.8 ± 9.5	51–90
Type C	11	61.4 ± 12.1	39–82
Overall	**50**	**72.9 ± 12.3**	**39–94**

The difference among the three fracture categories was statistically significant ($p < 0.001$). Post hoc analysis demonstrated significantly lower scores in type C fractures compared with type A fractures.

Range of Motion

At final follow-up, the mean active forward flexion was 136.8° ± 20.4°, mean abduction was 128.6° ± 22.7°, mean external rotation was 42.3° ± 11.6°, and mean internal rotation reached approximately the L2 vertebral level.

Table 8. Final shoulder range of motion

Movement	Mean ± SD
Forward flexion	136.8° ± 20.4°
Abduction	128.6° ± 22.7°
External rotation	42.3° ± 11.6°
Internal rotation	Median level: L2

Patients with type C fractures had lower mean forward flexion and abduction than patients with type A fractures.

Complications

Twelve patients experienced at least one complication. One patient experienced both shoulder stiffness and varus malunion, resulting in 13 recorded complication events among 12 patients.

Table 9. Postoperative complications

Complication	Number	Percentage

Shoulder stiffness	5	10.0
Subacromial impingement	3	6.0
Varus malunion	2	4.0
Superficial surgical-site infection	1	2.0
Intra-articular screw penetration	1	2.0
Avascular necrosis	1	2.0
Delayed union	3	6.0
Deep infection	0	0.0
Implant breakage	0	0.0
Nonunion	0	0.0

The superficial infection resolved with local wound care and oral antibiotics. The patient with screw penetration underwent early removal of the offending screw after fracture stability was confirmed. The patient with avascular necrosis remained under follow-up and had a poor Constant–Murley score at six months.

Factors Associated With Final Outcome

Increasing age was moderately associated with a lower final Constant–Murley score ($r = -0.39$, $p = 0.005$). Longer time to union was also associated with a poorer score ($r = -0.43$, $p = 0.002$).

Patients younger than 60 years had a higher mean score than those aged 60 years or older. Patients with complications had substantially lower final scores than those without complications.

Table 10. Factors associated with final Constant–Murley score

Factor	Mean score	p-value
Age below 60 years	76.8 ± 10.6	0.009
Age 60 years or above	67.0 ± 12.8	
No postoperative complication	77.1 ± 9.1	<0.001
At least one complication	59.5 ± 11.6	
Union by 16 weeks	74.5 ± 10.9	0.018
Delayed union	57.7 ± 9.5	
AO/OTA type A	80.1 ± 8.6	<0.001
AO/OTA type B	72.8 ± 9.5	
AO/OTA type C	61.4 ± 12.1	

DISCUSSION

The present study evaluated 50 patients with displaced proximal humerus fractures treated with locking-plate fixation. At six months, the mean Constant–Murley score was 72.9, and 68.0% of patients achieved good or excellent outcomes. The functional score improved significantly between six weeks, three months, and six months, demonstrating progressive recovery with fracture healing and rehabilitation.

The mean final score in the present series was comparable to the mean scores reported in systematic reviews of proximal humeral locking-plate fixation. Thanasas and colleagues reported that patients continued to improve during follow-up and achieved a mean Constant score of approximately 74.3. A separate systematic review involving 514 patients reported a mean Constant score of 74, although complication and reoperation rates remained substantial.

Südkamp and colleagues reported a mean Constant score of 70.6 at one year after open reduction and internal fixation. The mean score of 72.9 in the present study was within a similar range, although direct comparisons are limited by differences in patient age, fracture complexity, follow-up duration, operative technique, and score adjustment.

Functional Improvement

The serial improvement in Constant–Murley score was clinically and statistically significant. During the first six weeks, pain, immobilisation, muscle weakness, and restricted movement limited shoulder function. Improvement at three and six months reflected fracture consolidation, progressive mobilisation, recovery of muscle strength, and return to activities of daily living.

Locking plates provide angular stability and may facilitate early controlled movement when reduction and fixation are satisfactory. Nevertheless, good functional recovery depends on adherence to rehabilitation and preservation of soft-tissue vascularity and rotator-cuff function.

Influence of Fracture Complexity

AO/OTA type A fractures produced the best outcomes, while type C fractures produced the lowest mean scores. This relationship was expected because type C fractures involve the articular segment and are more frequently associated with comminution, disruption of medial support, tuberosity displacement, instability, and compromised vascularity.

Complex fracture morphology may also increase operative duration, soft-tissue dissection, difficulty in restoring anatomy, and the risk of postoperative stiffness or avascular necrosis.
The findings suggest that patients with type C fractures should receive realistic counselling regarding recovery time and possible functional limitations.

Fracture Union
Radiological union was achieved by 16 weeks in 94.0% of patients, while the remaining three fractures united by 24 weeks. No nonunion was observed.

Stable fixation, appropriate reduction, preservation of soft tissues, and controlled rehabilitation may have contributed to the high union rate. Locking plates do not depend entirely on plate-to-bone compression and can provide stable fixation in metaphyseal bone.

Delayed union was associated with a lower final functional score. Delayed healing prolongs pain and restricts rehabilitation, contributing to weakness and stiffness.

Importance of Medial Support
Varus collapse is an important complication of proximal humerus locking-plate fixation. Restoration of the medial column and appropriate inferomedial screw support improve the mechanical stability of the construct. Published evidence identifies the calcar region as an important anchor point and shows that reduction maintenance is influenced by fracture pattern, medial support, and implant positioning.

Two patients in the present study developed varus malunion. Both had complex fractures with medial comminution. Their final functional scores were lower than the study mean.

Complications
The overall patient-level complication frequency was 24.0%. This was lower than some early systematic reviews but remained clinically important. Locking-plate fixation has historically been associated with complication rates exceeding 20%, especially in older patients and complex fractures. Reported complications include screw cut-out, varus collapse, avascular necrosis, subacromial impingement, infection, and reoperation.

Shoulder stiffness was the most frequent complication in the present study. Stiffness may result from prolonged immobilisation, pain, capsular adhesions, soft-tissue injury, and delayed participation in rehabilitation. Early controlled mobilisation must be balanced against the risk of loss of reduction.

Subacromial impingement occurred in three patients. Excessively superior plate placement may lead to mechanical impingement during elevation. Correct plate positioning below the superior margin of the greater tuberosity is therefore important.

One patient developed intra-articular screw penetration. This complication may occur because of excessive screw length, collapse of the humeral head, or failure to assess screw position in multiple fluoroscopic projections. Careful intraoperative imaging and selection of screws that do not approach the subchondral surface excessively are required.

One patient developed avascular necrosis. The risk is influenced by fracture-dislocation, anatomical-neck involvement, medial-hinge disruption, calcar length, and soft-tissue vascular damage. Type C fractures may therefore require prolonged radiological follow-up because avascular necrosis may become apparent after the initial fracture has united.

Influence of Age
Older patients had lower final functional scores. Age-related differences may reflect poorer bone quality, greater fracture comminution, reduced healing capacity, pre-existing shoulder degeneration, reduced muscle strength, medical comorbidities, and difficulty participating in rehabilitation.

Locking plates provide angular stability in osteoporotic bone, but they do not eliminate the risk of fixation failure. Accurate reduction, medial support, appropriate screw placement, and careful rehabilitation remain essential.

Comparison With Published Evidence

The overall functional outcome in the present study was consistent with previous locking-plate series. A systematic review by Thanasas and colleagues reported a mean Constant score of approximately 74.3, while Sproul and colleagues reported a mean score of 74.

An Indian study of locking-plate fixation also used the Constant score and demonstrated good functional improvement with serial follow-up, although outcome categories and patient characteristics differed.
More recent studies continue to report satisfactory functional outcomes after PHILOS or similar locking-plate fixation when anatomical reduction and stable fixation are achieved. However, they also emphasise that technical errors and complex fracture patterns remain associated with complications.

Clinical Implications
Locking-plate fixation is most effective when the humeral head is reconstructible and stable anatomical or near-anatomical reduction can be achieved. Surgery should include restoration of head–shaft alignment, reduction of the tuberosities, preservation of soft-tissue attachments, restoration of medial support, appropriate plate height, and careful screw-length assessment.

Early rehabilitation should be tailored to fixation stability. Excessive immobilisation may cause stiffness, while overly aggressive early movement may contribute to loss of reduction.
Patients with type C fractures, poor bone quality, medial comminution, or delayed union require closer surveillance and more cautious rehabilitation.

Strengths
The study used a prospective design and a predefined follow-up protocol. Fractures were classified using the AO/OTA system, and functional assessment was performed serially using the Constant–Murley score.
Radiological union, functional recovery, range of motion, and postoperative complications were evaluated together. The study also examined the association of fracture complexity, age, complications, and union time with final shoulder function.

Limitations
The study was conducted at a single centre and included a relatively small sample. There was no comparison group treated nonoperatively, with intramedullary nailing, or with arthroplasty.

The minimum follow-up of six months was sufficient for early functional assessment but was inadequate for identifying every late case of avascular necrosis, post-traumatic arthritis, or delayed implant-related complication.

Bone-mineral density was not measured routinely, and the influence of osteoporosis could not be analysed directly. Reduction quality, medial support, and plate positioning were not graded using an independent blinded radiological assessment.

The Constant–Murley score includes strength measurements that may be influenced by pain, age, sex, motivation, and examiner technique. Age- and sex-adjusted Constant scores were not calculated.

Recommendations
Locking-plate fixation should be considered for displaced reconstructible proximal humerus fractures when stable reduction can be obtained.

Preoperative computed tomography should be used selectively for complex fractures. Surgical planning should assess tuberosity displacement, articular involvement, medial-column comminution, and humeral-head viability.

The plate should be positioned at an appropriate height and lateral location. Inferomedial support should be restored where possible, and screw length should be evaluated in multiple fluoroscopic views.

A structured rehabilitation protocol should be followed. Patients with complex fractures and complications require prolonged follow-up to identify avascular necrosis, secondary screw penetration, post-traumatic arthritis, and functional deterioration.

Larger multicentre studies with comparison groups and at least two years of follow-up are required.

CONCLUSION
Locking-plate fixation provided satisfactory fracture union and progressive functional improvement in most patients with displaced proximal humerus fractures.
At six months, 68.0% of patients achieved good or excellent Constant–Murley outcomes, and the overall mean score was 72.9. AO/OTA type A fractures had better outcomes than type B and type C fractures.

Shoulder stiffness was the most frequent complication. Subacromial impingement, varus malunion, superficial infection, screw penetration, and avascular necrosis occurred less frequently.
Accurate fracture reduction, restoration of medial support, correct plate placement, appropriate screw length, stable fixation, and structured rehabilitation are essential for favourable outcomes.

Declarations

Ethics Approval and Consent to Participate- The study was to be conducted after approval from the Institutional Ethics Committee of Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar. Written informed consent was to be obtained from all participants.

Availability of Data and Materials- The anonymised data supporting the study findings may be made available by the corresponding author upon reasonable request, subject to institutional and ethical requirements.

Competing Interests- The authors declare that they have no competing interests.

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