A Prospective Study of Surgical Management of Displaced Proximal Humerus Fractures with Interlocking Plating System

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Abstract: ***Introduction**: Proximal humerus fractures account for a significant proportion of all fractures, representing a major therapeutic challenge in orthopaedic trauma, especially within aging populations with poor bone quality. The management of displaced, unstable patterns remains highly controversial. Open reduction and internal fixation (ORIF) with the Proximal Humerus Internal Locking System (PHILOS) is increasingly preferred to counter these challenges by offering improved fixed-angle angular stability, reducing screw toggle risk, and optimizing functional recovery. **Aim of the study**: To evaluate the radiological and functional outcomes, as well as the complication profiles, of managing displaced proximal humerus fractures using an interlocking plating system. **Materials and Method**: This hospital-based prospective study was conducted involving 35 adult patients presenting with acute, closed, displaced Neer two-, three-, or four-part proximal humerus fractures treated via ORIF utilizing the PHILOS fixed-angle interlocking plating system executed through a uniform deltopectoral approach. Collected data included demographic parameters, mechanism of injury, fracture configurations, clinical and radiological union assessments, and postoperative functional updates quantified via the Constant-Murley Score and American Shoulder and Elbow Surgeons (ASES) score. **Results**: The mean age of the cohort was 51.37±12.23 years, with a distribution consisting of 22 males (62.9%) and 13 females (37.1%). Road traffic accidents (RTA) stood as the leading mechanism of injury (48.6%), and right-sided involvement was noted in 60.0% of cases. Neer three-part fractures represented the most prevalent pattern (48.6%). Complete radiological bone union was successfully achieved in 100% of the patients, exhibiting a mean union time frame of 12.49±1.48 weeks. The functional outcome scores yielded a final mean Constant-Murley score of 76.37±8.23 (with 77.1% grading as good-to-excellent) and a mean ASES score of 77.69±8.44. The overall complication rate was limited to 20.0%, occurring exclusively within complex Neer four-part fracture configurations (which showed a subgroup complication rate of 87.5%). **Conclusion**: The interlocking locking plate system stands as a reliable surgical treatment modality for displaced proximal humerus fractures, offering excellent structural stability, predictable radiological bone union, and optimal functional shoulder recovery. While functional results are excellent in two- and three-part fractures, complex Neer four-part configurations carry a distinctly elevated risk of complications.*

Keywords: Proximal Humerus Fracture; Humeral Head; Interlocking Plating System; PHILOS Plate; Constant-Murley Score; Bone Union

1. Introduction

Proximal humerus fractures account for approximately 4% to 5% of all fractures, representing the third most common fracture pattern in the elderly population. The optimal management of displaced, unstable two-, three-, and four-part fractures remains a topic of active clinical controversy. Poor bone quality, profound osteopenic bone, and complex regional anatomy frequently complicate stable internal fixation, leading to high failure rates when utilizing conventional extramedullary implants. Non-operative management is reserved primarily for non-ambulatory patients or those with high perioperative mortality risks, but frequently culminates in poor long-term outcomes owing to malunion, stiffness, or systemic recumbency complications.

The introduction of fixed-angle locking plate systems, such as the Proximal Humerus Internal Locking System (PHILOS), was designed to counter these challenges. These advanced locking constructs minimize the risk of mechanical screw failure and pull-out owing to their angular stability, which acts as a sound internal fixator even within poor bone stock. Meticulous fixed-angle configurations also preserve proximal humeral biology by acting as limited-contact plates, preventing excessive periosteal stripping and protecting the vital vascularity of the humeral head. Meticulous clinical trials have demonstrated superior structural preservation of fracture reduction with these devices. In this prospective clinical study, our objective is to systematically evaluate the radiological success, functional safety, and final clinical outcome profiles of displaced proximal humerus fractures managed via the interlocking plating system.

2. Materials and Method

Our study was a prospective observational clinical study conducted at Navodaya Medical College Hospital & Research Centre evaluating 35 adult patients presenting with acute, closed, displaced Neer two-, three-, or four-part proximal humerus fractures treated via an interlocking plating system. The study was performed across a dedicated clinical tracking timeline.

Inclusion Criteria:
- Skeletally mature adult patients presenting with acute, closed, displaced proximal humerus fractures.
- Fractures classified under Neer's classification as two-part, three-part, or four-part configurations.
- Injuries presenting within two weeks of initial trauma.
- Patients fit for anesthesia and providing explicit informed consent.

Exclusion Criteria:
- Open fractures or compound injuries.
- Pathological fractures secondary to underlying neoplastic or metastatic diseases.
- Fractures associated with concurrent neurovascular deficit or acute nerve injury.
- Patients presenting with prior history of ipsilateral shoulder operations or major congenital anomalies.

Preoperative Protocol:
Complete medical data was systematically recorded within a specially structured Case Record Form (CRF), capturing detailed clinical histories, mechanism of injury, and relevant pre-anesthesia investigations. Standard clinical assessments quantified baseline vitals and documented associated systemic co-morbidities. Radiographic evaluation consisted of high-quality anteroposterior (AP) views and axillary or scapular-Y views of the affected shoulder to precisely delineating the fracture pattern, segment displacement, and overall orientation. The affected upper limb was initially supported and immobilized within a standard shoulder sling or U-slab.

Surgical Technique and Postoperative Care:
All operative procedures were executed under general or regional interscalene anesthesia. Patients were optimally positioned in a beach-chair or supine setup under C-arm fluoroscopic guidance. A standardized deltopectoral surgical approach was strictly utilized. Minimal soft tissue stripping was rigorously maintained throughout to protect the residual vascularity supplying the humeral head fragments. Following successful anatomical open reduction, the fracture fragments were temporarily pinned, and the fixed-angle PHILOS interlocking plate was adapted precisely onto the lateral surface of the humerus under strict fluoroscopic confirmation. Retractor stress was minimized to avoid neurovascular compromise.

Postoperatively, the upper limb was safely immobilized in a standard shoulder sling. Phased physical therapy and standardized rehabilitation began safely from the first postoperative week, initiating gentle passive range-of-motion exercises as tolerated. Active assisted exercises and progressive strengthening protocols were progressively added. Patients were thoroughly followed up clinically and radiographically at regular post-discharge intervals (including 3 weeks, 6 weeks, 3 months, and 6 months). Long-term tracking assessed bone healing timelines, structural alignment, and functional parameters utilizing the Constant-Murley Score and American Shoulder and Elbow Surgeons (ASES) scale.

3. Results

The baseline clinical profile comprised 35 patients ranging from a minimum age of 29 years to a maximum age of 74 years, with an overall mean age of 51.37±12.23 years. The distribution showed a higher concentration within the middle-to-elderly age groups. The age metrics of the study cohort are structured in Table 1.

Table 1: Age Distribution of the Study Cohort

Age Cohort (Years)	Number of Patients	Percentage (%)
≤40	7	20.0%
41–50	10	28.6%
51–60	9	25.7%
>60	9	25.7%
Total	35	100.0%

Patient sex distribution demonstrated a male predominance, containing 22 males (62.9%) and 13 females (37.1%). In terms of injury mechanisms, high-energy trauma secondary to road traffic accidents (RTA) was identified as the leading cause of injury in 17 patients (48.6%). Accidental or trivial falls were reported in 15 patients (42.9%), while fall from heights accounted for the remaining 3 patients (8.6%). The injury etiology is described in Table 2.

Table 2: Mode of Injury Distribution

Mode of Injury	Number of Patients	Percentage (%)
Road Traffic Accident (RTA)	17	48.6%
Accidental/Trivial Fall	15	42.9%
Fall from Height	3	8.6%
Total	35	100.0%

Right-sided shoulder involvement was noted in 21 cases (60.0%), whereas left-sided injuries occurred in 14 cases (40.0%). Associated mild system-based comorbidities, including type 2 diabetes mellitus and systemic hypertension, were documented and managed under appropriate specialist supervision prior to surgical authorization. According to Neer's classification framework, 10 patients (28.6%) sustained two-part fractures, 17 patients (48.6%) presented with three-part fractures, and 8 patients (22.9%) presented with complex four-part fractures.

All 35 patients progressed to complete radiological bone union. The average time interval to achieve stable radiological healing was 12.49±1.48 weeks. Eleven patients demonstrated solid union by 11 weeks, while the remaining patients consolidated within standard physiologic limits. The distribution of fracture union timelines is shown in Table 3.

Table 3: Duration of Radiographic Fracture Union

Fracture Union Timeline (Weeks)	Number of Patients	Percentage (%)
10–11	11	31.4%
12–13	16	45.7%
14–15	8	22.9%
Total	35	100.0%

Adverse events and postoperative complications were observed in 7 patients out of the 35 overall cases, reflecting an overall complication rate of 20.0%. Crucially, all 7 recorded complications were located within the complex Neer 4-part fracture subgroup (n=8), representing an isolated subgroup complication rate of 87.5% within that category. These complications included persistent shoulder joint stiffness (n=3), varusmalunion (n=2), intra-articular screw perforation (n=1), and avascular necrosis (AVN) of the humeral head fragment (n=1). No instances of superficial or deep surgical site infection, implant breakdown, or screw back-out were observed in the two-part or three-part injury groups. Postoperative complications are categorized in Table 4.

Table 4: Postoperative Complications

Complication Profile	Number of Patients	Percentage (%)
Persistent Shoulder Stiffness	3	8.6%
VarusMalunion	2	5.7%
Intra-articular Screw Perforation	1	2.9%
Avascular Necrosis (AVN)	1	2.9%
Total	7	20.0%

Functional objective scoring evaluated via the Constant-Murley Score demonstrated progressive recovery during successive clinical appointments. The mean Constant-Murley score at the final assessment was 76.37±8.23, matching a highly favorable overall clinical recovery profile. The corresponding final mean ASES functional tracking score was 77.69±8.44. Excellent functional outcomes were found in 6 patients (17.1%), Good recovery in 21 patients (60.0%), Fair ratings in 6 patients (17.1%), and Poor functional restoration in 2 patients (5.7%). Functional criteria are detailed in Table 5.

Table 5: Functional Outcome Category via Constant-Murley Rating

Functional Outcome Category	Patient Count (n=35)	Percentage (%)
Excellent (86–100)	6	17.1%
Good (71–85)	21	60.0%
Fair (56–70)	6	17.1%
Poor (≤55)	2	5.7%
Total	35	100.0%

4. Discussion

A wide variety of operative fixation devices, ranging from conservative percutaneous pinning to extensive structural extramedullary locking plates, have been utilized to address displaced proximal humerus fractures. However, considerable debate persists regarding the ideal implant choice, particularly in patients presenting with compromised structural anatomy or osteoporotic bone tissue. The structural biomechanical properties inherent to the fixed-angle locking system have provided dependable clinical performance. For many years, conventional non-locking plates were used but carried higher rates of failure due to screw pull-out or toggle. In recent years, internal locking plates like the PHILOS system have emerged as a primary option, because they are easier to utilize and supply superior structural holding strength without compromising periosteal blood supply. The fixed-angle construct is mechanically optimized as it transmits joint forces smoothly across the lateral humeral cortex, permitting early mobilization, reducing stiffness, minimizing infection risks, and ensuring strong internal stability.

Our present study demonstrated an absolute 100% radiographic bone union rate, matching an average union timeline of 12.49 weeks, which correlates directly with global literature tracking fixed-angle humeral devices. The final objective functional shoulder recovery was found to be highly successful, returning good-to-excellent results in 77.1% of our patients.

Importantly, our data confirms that the structural complexity of the fracture configuration directly dictates the overall complication profile. While patients sustaining displaced Neer two-part or three-part fracture patterns recovered predictably without significant structural complications, the four-part fracture configurations demonstrated considerable vulnerability. Out of 8 patients presenting with four-part fractures, 7 developed complications, representing a subgroup risk of 87.5%. This high rate is due to the extensive periosteal devitalization, fracture fragmentation, and compromised articular blood flow inherent to high-energy four-part injuries. Therefore, while the interlocking plating system provides excellent fixed-angle stability, absolute surgical precision, anatomical alignment, and deliberate patient selection remain mandatory when treating complex four-part fracture configurations.

The limitations of our study include a relatively modest patient sample size, which may restrict immediate generalization to broader demographic populations. Patients were monitored over a short-term tracking period; longer observational parameters would provide deeper insights into late complications, such as long-term joint arthrosis or chronic avascular remodeling. Furthermore, being a single-center trial conducted within one institution, a degree of institutional bias cannot be entirely excluded. The lack of a concurrent randomized control or comparative group prevents direct comparative evaluation against alternative modern treatments, such as primary hemiarthroplasty or reverse shoulder arthroplasty, for complex fracture patterns. Nevertheless, our findings serve as a robust clinical reference for managing proximal humeral injuries with locking plates.

5. Conclusion

We conclude that stabilizing displaced proximal humerus fractures with an interlocking fixed-angle locking plate system is an effective surgical modality, providing dependable biomechanical stability, excellent bone union rates, and highly favorable functional shoulder restoration. The configuration of the fixed-angle locking screws offers a distinct load-sharing advantage, counters deforming muscles forces, and protects the underlying biology of bone healing through a limited-contact design. These internal adjustments optimize the quality of structural alignment and support early physical therapy, particularly within displaced two-part and three-part fracture configurations.

Despite these clear mechanical advantages, potential complications such as post-traumatic joint stiffness, varus collapse, screw articulation perforation, and avascular necrosis must be kept in mind when dealing with complex fracture types. The risk of these adverse outcomes can be reduced through accurate preoperative planning, soft tissue

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protection, proper plate alignment, and structured postoperative rehabilitation. In conclusion, the interlocking plating system represents a safe, reliable, and biomechanically sound option for managing displaced proximal humerus fractures, resulting in predictable healing and satisfactory functional recovery when sound surgical principles are maintained.

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