

Assessment of Functional Outcomes of Proximal Humerus Fractures Treated by Open Reduction and Internal Fixation using Proximal Humerus Locking Plate

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Received: 16-08-2023 / Revised: 28-09-2023 / Accepted: 23-10-2023

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Conflict of interest: Nil

Abstract:

Background: The management of proximal humeral fractures that are unstable and displaced, particularly in elderly individuals, continues to be a topic of debate. This prospective study aimed to assess both the functional outcome and complication rate associated with employing locking proximal plates in open reduction and internal fixation for treating these fractures.

Methods: Patients with fractures in the proximal humerus were eligible for inclusion if they were over eighteen years old, had achieved skeletal maturity, and provided written informed consent before participating in the study. Fractures were considered for operative treatment based on Neer's criteria (angular articular surface angulation $>45^\circ$ or displacement >1 cm between major fracture segments) or if they demonstrated instability during passive motion under an image intensifier.

Results: Proximal humerus fractures are more common in younger adults, with the majority of cases occurring in the 21-30 age group. Road traffic accidents are the leading cause of proximal humerus fractures, especially in men. Three-part fractures are the most common type of proximal humerus fracture. Most patients undergo surgery within 1-3 days of injury. At 12 months after surgery, the mean ROM in all four movements was within the normal range. The mean CMS score at 12 months was 76.61, which is considered to be a good score. The complication rate was relatively low, with the most common complication being stiffness (8%).

Conclusion: Among proximal humerus fractures, three-part fractures were identified as the most common type. The majority of patients underwent surgery within 1-3 days post-injury. After a 12-month post-surgery period, the mean range of motion (ROM) across all four movements was within the normal range. Overall, the study underscores the safety and efficacy of employing a proximal humerus locking plate for treating such fractures. There is a significant improvement in shoulder function post-surgery, with most achieving a normal ROM and displaying favorable functional outcomes at the 12-month mark.

Keywords: Proximal Humerus Fractures, Open Reduction, Internal Fixation, Locking Compression Plates, Postoperative Functional Outcome.

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Introduction

Approximately 5% of all fractures are proximal humeral fractures, and the majority (75%) of these occur in individuals over the age of sixty. [1, 2] The majority of these fractures in the elderly population are linked to osteoporosis. [3] Fractures that are nondisplaced or have minimal displacement and sufficient stability often respond

well to nonoperative treatments. [4] On the contrary, managing fractures that are displaced and lack stability remains a contentious issue. Internal fixation has shown unpredictable outcomes, especially in patients with osteopenic bone or those with comminuted fractures. Various treatment approaches have been suggested, including open

reduction and internal fixation with proximal humeral plates, hemiarthroplasty, and percutaneous or minimally invasive techniques such as pinning, screw osteosynthesis, and intramedullary nail usage. [5-8] However, these techniques have been associated with several complications such as implant failure, loss of reduction, non-union or malunion of the fracture, impingement syndrome, and osteonecrosis of the humeral head. [9, 10] To mitigate these complications, the AO Foundation developed the Locking Proximal Humerus Plate. [11] This device is pre-contoured to match the lateral aspect of the proximal humeral metaphysis, aiding in internal fixation by achieving an anatomically reduced position with angular stability. A recent biomechanical analysis comparing blade-plate fixation with locking plate fixation for proximal humeral fracture treatment revealed potential advantages with the use of locking plates. However, there is a limited number of prospective clinical studies reporting outcomes after locking plate fixation for proximal humeral fractures, and most of these studies have included a small patient population. [12, 13] The objective of the study was to assess the functional outcomes and complication rates following the internal fixation of proximal humeral fractures using the Locking Proximal Humerus Plate.

Material and Methods

This prospective study was conducted in the Department of Orthopedics, Government Medical College and Hospital, Wanaparthy, Telangana State. Institutional Ethical approval was obtained for the study. Written consent was obtained from all the participants of the study after explaining the nature of the study in the vernacular language.

Patients with fractures in the proximal humerus were eligible for inclusion if they were over eighteen years old, had achieved skeletal maturity, and provided written informed consent before participating in the study. Fractures were considered for operative treatment based on Neer's criteria (angular articular surface angulation $>45^\circ$ or displacement >1 cm between major fracture segments) or if they demonstrated instability during passive motion under an image intensifier. Fractures that were stable and nondisplaced or had minimal displacement and adequate stability, as well as those involving only the greater or lesser tuberosity, were not selected for treatment using the Locking Proximal Humerus Plate. Exclusion criteria comprised open fractures, pathological or refractures, pseudarthrosis, prior surgical treatment in the proximal humerus, concurrent ipsilateral fractures of the distal humerus or elbow joint, polytrauma with an Injury Severity Score exceeding 16, existing disorders affecting the healing process (e.g., multiple sclerosis, paraplegia), posttraumatic brachial plexus injury, or

peripheral nerve palsy. The Locking Proximal Humerus Plate is an implant specifically designed for fixing proximal humeral fractures. It is anatomically contoured to the lateral aspect of the proximal humeral metaphysis and the proximal part of the humeral diaphysis, acting as an internal fixator to secure anatomic reduction with angular stability. The screw configuration of the locking screws within the humeral head allows multidirectional placement. In the shaft, combination holes can accommodate either locking or non-locking screws. Additional smaller holes can be used to secure sutures or wires, facilitating the reattachment of the greater or lesser tuberosities in cases of comminuted fractures, and neutralizing the tension forces exerted by the rotator cuff muscles. The plate is available in two lengths, featuring five or eight combination holes in the shaft component. Besides the Locking Proximal Humerus Plate, several other designs of proximal humeral implants are also available.

The surgical procedure was carried out with the patient positioned either supine or in a beach-chair posture on a radiolucent table, utilizing a deltopectoral or deltoid-splitting surgical approach based on the preference of the surgical center. The fracture was initially reduced and provisionally stabilized using threaded Kirschner wires. The adequacy of this reduction was confirmed using image intensification. The Locking Proximal Humerus Plate was positioned, with assistance from a mounted aiming device, at least 5 to 8 mm distal to the upper end of the greater tuberosity and 2 mm posterior to the bicipital groove, ensuring a sufficient gap between the plate and the tendon of the long head of the biceps. Once fracture reduction and screw positioning were deemed satisfactory, the plate was definitively fixed by inserting angular stable screws into the humeral head. The decision to use angular stable or standard cortical screws for the humeral shaft holes was at the discretion of the treating surgeon. A final verification of correct screw placement was performed using an image intensifier, as decided by the surgeon. Postoperatively, the arm was immobilized in a sling, and passive range-of-motion exercises were initiated within two days after the surgery. Controlled active mobilization involving abduction and flexion beyond 90° commenced between one to three weeks postoperatively, depending on osteosynthesis stability and bone quality. Throughout the hospital stay, demographic details and baseline characteristics of the patients were documented. Fractures were classified using the AO system by the treating surgeon based on plain radiographs and intraoperative fracture visualization. Scheduled follow-up assessments were conducted at three, six, and twelve months postoperatively. During each follow-up, patients were examined and interviewed regarding pain,

mobility, strength, and the Constant score of both the injured and contralateral shoulders. Strength tests were carried out with the shoulder at 90° of abduction or, if 90° could not be achieved, in maximum active abduction as described by Constant and Murley. Patients were instructed to maintain resisted abduction for five seconds. The mean of three tests was recorded as the shoulder's strength. Patients with a history of trauma or prior surgery involving the contralateral shoulder were excluded from the mean contralateral Constant score. Additionally, the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, a validated patient-focused outcome tool, was administered during the one-year follow-up. True anteroposterior and trans scapular Y-view radiographs were taken postoperatively and at each follow-up. The treating surgeon primarily evaluated radiographs for fracture healing and potential complications. All radiographs were also reviewed by the principal investigator (N.S.) and radiologists at the central study monitoring organization. Reported complications were confirmed and

categorized based on the most probable influencing factor, considering relevant plain radiographs and additional submitted clinical data.

Results

Table 1 shows the demographic profile of 25 patients with proximal humerus fractures included in this study. There were 14(56%) male patients and 11(44%) female patients. The most common age group was 21-30, with 7 patients (28%). The least common age group was 18-20, with 2 patients (8%). The mean age of the cohort was 35.5 ± 5.5 years. The table shows that proximal humerus fractures are more common in younger adults, with the majority of cases occurring in the 21-30 age group. This is likely due to the fact that younger adults are more likely to participate in activities that put them at risk for these types of fractures, such as sports and recreational activities. There is a slight male predominance for proximal humerus fractures. This is consistent with previous studies, which have shown that men are more likely to experience these types of fractures than women.

Table 1: Demographic profile of the cases with proximal humerus fractures included in the study

Age group	Male	Female	Total (%)
18 – 20	1	1	2 (8)
21 – 30	5	2	7 (28)
31 – 40	3	1	4 (16)
41 – 50	1	3	4 (16)
51 – 60	2	2	4 (16)
61 – 70	2	2	4 (16)
Total	14	11	25 (100)

Table 2 shows the cause of proximal humerus fractures in 25 patients. The most common cause was road traffic accidents (72%), followed by falls from height (24%) and seizures (4%). Road traffic accidents are the leading cause of proximal humerus fractures, especially in men. This is likely due to the fact that men are more likely to be involved in high-energy trauma, such as car accidents. Falls

from height are the second most common cause of proximal humerus fractures, especially in women. This is likely since women have weaker bones than men and are more likely to fall from heights, such as ladders or stairs. Seizures are a relatively rare cause of proximal humerus fractures. However, they can occur in patients with certain medical conditions, such as epilepsy or cerebral palsy.

Table 2: Showing the cause of proximal humerus fractures in cases of the study

Humerus fractures cause	Male	Female	Total (%)
Road Traffic Accidents	10	8	18 (72)
Fall from height	3	3	6 (24)
Seizures	1	0	1 (4)
Total	14	11	25 (100)

Neer's classification: Two-part fractures: These fractures involve two of the four segments of the proximal humerus: the humeral head, greater tuberosity, lesser tuberosity, and humeral shaft. Three-part fractures: These fractures involve three of the four segments of the proximal humerus. Four-part fractures: These fractures involve all four segments of the proximal humerus. Table 3 shows the distribution of 25 cases of proximal humerus fractures based on Neer's classification and time of

injury to surgery. The table shows that three-part fractures are the most common type of proximal humerus fracture, accounting for 52% of cases. Four-part fractures are less common, but still significant, accounting for 28% of cases. Two-part fractures are the least common, accounting for 20% of cases. The table also shows that the majority of patients with proximal humerus fractures undergo surgery within 1-3 days of injury. This is because early surgery is associated with better outcomes.

The choice of surgical approach and timing of surgery for proximal humerus fractures depended on several factors, including the type of fracture,

the patient's age and overall health, and the patient's activity level.

Table 3: Distribution of cases of proximal humerus fractures based on Neer's classification and time of injury to surgery

Humerus fractures Neer's Classification	Male	Female	Total (%)
Two part	2	3	5(20%)
Three part	8	5	13(52%)
Four-part	4	3	7(28%)
Duration of injury to surgery			
1 – 3 days	11	7	18(72%)
4 – 6 days	1	3	4(16%)
7 – 10 days	1	1	2(8%)

Table 4 shows the mean range of motion (ROM) in four different shoulder movements at different follow-up times after proximal humerus locking plate surgery in 25 patients. The ROM in all four movements improved significantly over the course of the study. The greatest improvement was seen between

6 weeks and 3 months, with smaller improvements seen at 6 months and 12 months. At 12 months, the mean ROM in all four movements was within the normal range. This suggests that proximal humerus locking plate surgery can be an effective way to restore ROM in the shoulder after a fracture.

Table 4: Mean range of movements recorded post-surgery in 25 cases of the study

Movements	Follow up time			
	6 weeks	3 months	6 months	12 months
Forward flexion	61.52 °	101.35 °	123.67 °	144.55 °
Abduction	57.66 °	103.22 °	119.16 °	142.97 °
Internal rotation	38.55 °	50.24 °	63.33 °	67.89 °
External Rotation	28.18 °	43.28 °	55.67 °	64.55 °

The Constant Murley Shoulder Score (CMS) is a questionnaire that is used to assess the functional status of the shoulder (Table 5). It is a 100-point scale, with higher scores indicating better function. The table shows that the mean CMS score improved significantly over the course of the study. The greatest improvement was seen between 6 weeks and 3 months, with smaller improvements seen at 6 months and 12 months. At 12 months, the mean CMS score was 76.61. This is considered to be a good score, and it suggests that the patients in

the study were able to regain a significant amount of function in their shoulder after surgery. It is important to note that the CMS score is just one measure of shoulder function. Other factors, such as pain, strength, and range of motion, also need to be considered when assessing a patient's recovery. Overall, the results of this study are encouraging and suggest that proximal humerus locking plate surgery can be an effective way to improve shoulder function after a fracture.

Table 5: The mean Constant Murley scores at different intervals post-surgery in 25 cases of the study

Follow up time	Range of scores	Mean	± SD
6 weeks	9 – 35	25.29	8.89
3 months	31 – 62	46.55	12.35
6 months	34 – 81	60.73	17.65
12 months	36 – 89	76.61	19.88

Table 6 shows the frequency and percentage of complications recorded in 25 patients who were treated for proximal humerus fractures with open reduction and internal fixation using a proximal humerus locking plate. The most common complication was stiffness, which occurred in 8% of patients. Other complications included infected implant (4%), varus malunion (4%), and subacromial

plate impingement (4%). Other complications include nerve injury, vascular injury, and non-union which were not present in any of our cases of the study. Overall, the complication rate in this study is relatively low. This suggests that proximal humerus locking plate surgery is a safe and effective way to treat proximal humerus fractures.

Table 6: Complications recorded in 25 cases treated by open reduction and internal fixation using Proximal Humerus Locking Plate

Complications	Frequency	Percentage
Infected implant	1	4
Stiffness	2	8
Varus malunion	1	4
Subacromial plate impingement	1	4
Varus malunion with intraarticular screw cut out	0	0
Nerve injury	0	0
Vascular injury	0	0
Non-union	0	0

Discussion

In recent years, the occurrence of proximal humeral fractures (PHFs) has risen, attributed to shifts in lifestyle and a surge in road traffic accidents. Determining an optimal management approach for PHFs remains unclear. Typically, conservatively treating undisplaced PHFs is viable, but managing displaced fractures or fracture-dislocations poses a challenge, even with a comprehensive analysis and understanding of the injury. Various published studies suggest that displaced fractures of the proximal humerus result in a diminished functional prognosis due to the significant displacement of fragments. [14-16] The mean age of the cohort in this study was 35.5 ± 5.5 years. The mean age at incidence was reported as 54.3 ± 5.8 years in the research conducted by Doshi C et al. [17] 38 years (ranging from 24 to 68) in the study conducted by Kumar GK et al. [18] 58 years (ranging from 22 to 78) according to the study conducted by Sreen S et al. [19], and 49.24 years as per the study by Bansal V et al. [20]. Existing literature indicates a higher occurrence of proximal humeral fractures among elderly females. Nonetheless, in this current study, there were 14(56%) male patients and 11(44%) female patients. Studies conducted by Gerber et al. [21] Aggarwal et al. [22] and Sachde et al. [23] have indicated a higher susceptibility of males to proximal humeral fractures (PHFs) compared to females. Similarly, the present study also demonstrated a greater incidence of PHFs in men than in women, potentially attributed to the higher engagement of males in daily activities. Fall on an outstretched hand was identified as the primary cause of PHFs in published reports by Fazal et al. [24] Aggarwal et al. [22] Sachde et al. [23] and Gaheer et al. [25] rather than road traffic accidents. This study found RTA was the common cause of proximal humerus fractures. Furthermore, the current investigation revealed a significantly higher incidence of PHFs on the right-hand side (aligning with the observation in Gerber et al.'s report [21]). Most frequently, three-part PHFs were reported in the literature by Brunner et al. and Gaheer et al. [25], and these fractures were typically managed through open reduction and internal fixation employing the PHILOS plate the current study's

findings aligned with these observations, revealing that 13 out of 25 patients had three-part proximal humeral fractures (PHFs) and were managed using either PHLP or PHILOS plates. [25, 26] The existing literature, including studies by Brunner et al. [26] Aggarwal et al. [22] Sachde et al. [23], and Gaheer et al. [25] commonly reported postoperative complications such as infection, malunion, avascular necrosis, impingement, stiffness, screw penetration, or screw loosening. In the present study, postoperative complications were observed, including stiffness and malunion (6.45%), and less frequently, infection, impingement, and screw penetration (3.22%).

The outcomes of this study were assessed using the Constant and Murley scoring criteria. The findings indicated good to excellent results in 18(72%) and moderate results in 4 patients (16%). According to the Constant and Murley scoring criteria, all patients exhibited normal muscle physiology and a functional range of motion. A poor result was observed in 3 patients (12%). Among them, one patient experienced plate impingement and restricted abduction due to the higher placement of the plate, nearly aligning with the greater tuberosity. Another patient developed varus malunion, likely resulting from a neck-shaft angle less than 120° , possibly due to comminution of the osteoporotic bone, causing impaction at the fracture site after reduction and leading to varus malunion. Two patients (8%) reported stiffness with restricted movements and persistent mild pain. Intensive physiotherapy sessions resulted in some improvement in one of these patients, with a final Constant score of 55 at the last follow-up. The other patient underwent shoulder manipulation under anesthesia, leading to some improvement, achieving a final Constant score of 54. One patient experienced a deep infection that necessitated implant removal and debridement. Despite good fracture union observed in the radiograph, prolonged antibiotic therapy was required to resolve the infection. This patient achieved a final Constant score of 39 during the last follow-up. Some of the important limitations of the current study were due to the small sample size of the study group, and more definitive results and

recommendations could have been made with a larger sample size. A longer follow-up duration could have provided a clearer understanding of avascular necrosis incidence, contributing to a better correlation between the management strategy and outcomes. Additionally, an inevitable limitation was the potential difficulty of implant removal, a consideration that patients with proximal humeral fractures need to bear.

Conclusion

The study found that proximal humerus fractures are more common in younger adults, with the majority of cases occurring in the 21-30 age group. Road traffic accidents are the leading cause of proximal humerus fractures, especially in men. Falls from height are the second most common cause, especially in women. Three-part fractures are the most common type of proximal humerus fracture. Most patients undergo surgery within 1-3 days of injury. At 12 months after surgery, the mean ROM in all four movements was within the normal range. The mean CMS score was 76.61, which is considered to be a good score. The complication rate was relatively low, with the most common complication being stiffness (8%). Overall, the study suggests that proximal humerus locking plate surgery is a safe and effective way to treat proximal humerus fractures. There is a significant amount of function in their shoulder after surgery, with most patients achieving a normal ROM and good functional outcomes at 12 months.

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