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Original Research Article

Functional outcome of proximal humerus locking plate in displaced proximal humerus fractures- A prospective study

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ABSTRACT

Aim and Objectives: To analyze the functional outcomes of patients with proximal humerus fracture with philos plate fixation.

Materials and Methods: This prospective study encompasses a cohort of 20 patients diagnosed with displaced fractures of the proximal humerus, categorized according to Neer's classification. Aged between 22 - 66 years who all sustained trauma to limb. Pathological and undisplaced patterned proximal humerus fractures were excluded from this study. All the patients underwent open reduction and internal fixation with philos plate in Department of Orthopaedics at MM Institute of Medical Sciences and Research during the study period.

Result: Average age of patients included into this study was 46.95 years. Average time taken from injury to surgery was 7.85 days. Delto-pectoral and deltoid splitting approach was used in the cases included in this study, to gain access to proximal humerus. In this study we have used Constant score along with Neer's classification for proximal humerus fracture to assess the functional outcome of all the cases. We have obtained 25% excellent, 30% good, 30% moderate and 15% poor functional outcome measured by Constant score.

Conclusion: In our study 20 patients having displaced proximal humerus fracture of Neer's classification included, 17 patients (85%) had excellent to moderate outcomes with proximal humerus internal locking system. The utilization of stable and rigid fixation provided by Philos plate fixation offers several advantages. Early mobilization facilitated by this technique enables patients to swiftly return to their pre-fracture functional status, consequently reducing the risk of shoulder stiffness, restricted range of motion, head collapse, and ultimately enhancing their overall quality of life. Proximal humerus. The choice of surgical approach and type of implant employed is contingent upon several factors, including the fracture pattern, bone quality, patient's objectives, and the surgeon's proficiency with various techniques. Additionally, the learning curve associated with selected implants significantly influences decision-making. Employing an appropriate surgical technique can mitigate complications, while a rigorous rehabilitation regimen contributes to achieving optimal outcomes. Despite the limitations of our study, namely its relatively short duration and lack of randomization, our findings align with those reported in other scholarly publications.

1. Introduction

Proximal humerus fractures represent 4% of all fractures and 26% of humerus fractures,[1] common among older adults, ranking third after hip and distal radius fractures.

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The proximal humerus includes the humeral head, greater and lesser tuberosities, and the proximal humeral shaft. Osteoporosis is a major cause in the elderly, while high-energy trauma is less common in younger adults.[2] These fractures often result from high-energy trauma and dislocation, challenging surgeons due to osteoporotic bone quality and muscle forces. Most are stable and minimally displaced, suitable for non-operative treatment.[3] About 80% of humerus fractures are proximal, with 20% requiring surgery for better mobility or due to severity. The Neer classification system, despite limitations, categorizes these fractures by displacement and angulation, guiding treatment. Non-operative management, including immobilization and rehabilitation, suffices for non-displaced fractures, while complex cases may require surgical interventions like open reduction, internal fixation, or arthroplasty. Displaced 3-part or 4-part fractures can disrupt the glenohumeral joint and compromise blood supply, impacting healing. Stable fixation is crucial, with methods like K-wire pinning, screw fixation, plates, and prosthetic replacement, each with potential complications. Poor bone quality in the elderly heightens the risk of fixation failure.[4–6] The Proximal Humerus Internal Locking System (PHILOS) addresses these issues, enabling early mobilization and reducing shoulder stiffness, even in minimally displaced fractures. For highly comminuted fractures, PHILOS with rotator cuff sutural ties improves outcomes. This study highlights the effectiveness of the PHILOS plate in managing proximal humerus fractures.

2. Classification

The Neer classification system[7,8] relies on displacement criteria of 1 cm or fragment angulation of 45°. Fractures are categorized into segments, with four possible segments: the articular segment, the lesser tuberosity, the greater tuberosity, and the surgical neck. These segments are demarcated by epiphyseal lines (bone growth plates) during early development. Fracture lines in the proximal humerus typically occur along one or more of these planes.

Additionally, recent criteria consider displacement of the greater tuberosity exceeding 5 mm as an indication for fixation.

3. Materials and Methods

This prospective study encompasses a cohort of 20 patients diagnosed with displaced fractures of the proximal humerus, categorized according to Neer's classification. Aged between 22 - 66 years who all sustained trauma to limb. Pathological and undisplaced patterned proximal humerus fractures were excluded from this study. All the patients underwent open reduction and internal fixation with philos plate. Patient data recorded included age, profession, sex, mechanism of injury, injury severity, associated injuries, time since injury, and functional demands. Radiographic evaluation, including standard and special views, was used to confirm the diagnosis. In cases where the fracture geometry was uncertain, thin-slice CT scans were used to assess the intra-articular extent of the fracture

The fracture was classified according to the Neer's Classification system, and a pre-operative plan was developed based on this classification. Prior to surgery, the patient was managed with analgesics and immobilization in a U-slab. Additionally, any co-morbidities were addressed and treated as necessary.

During surgery, any events, difficulties, or complications were recorded. Post-operative radiological assessments and monitoring of bony union were conducted. Patients were regularly followed up at specified intervals (3 weeks, 6 weeks, 3 months, 6 months, and 12 months) for radiographic evaluation and clinical examination to track their progress and outcome. At the final assessment, all patients underwent a thorough evaluation, encompassing both radiological as well as functional assessments utilizing the Constant score, to ascertain their overall outcome and functional status.

Pre-op clinical evaluation- Following hemodynamic stabilization, a comprehensive history was obtained from patients admitted to the Department of Orthopedics & Traumatology, focusing on the mode of injury, clinical history, presence of any co-morbidities, and clinical examination.

All patients received preoperative treatment with appropriate analgesics and antibiotics if necessary. Subsequently, they were splinted with a U-slab or cuff and collar to alleviate pain, restrict unnecessary movement of the injured limb, and prevent damage to the neurovascular bundle.

Radiological evaluation- Following radiographs were taken in every case:

1. Antero-posterior view (Grashey's view)
2. Lateral view (Neer's-Y view)
3. Axillary view

The records were examined to determine the Neer classification of the fracture. In specific cases, CT scans or special views were utilized to assess the extent of involvement of the articular surface.

Selection of cases by inclusion criteria including patients with displaced proximal humerus fracture, classified on basis of Neer's classification. Patients with closed fractures of proximal humerus. Failure of conservative treatment method and associated ipsilateral dislocation of shoulder and exclusion criteria including metastatic & pathological fractures of proximal humerus. Children between age of 0-14 years and undisplaced fractures of proximal humerus are excluded.

Preoperative planning goals of treatment include evaluating the functional outcome in patients treated with

Proximal Humerus Locking Plate for displaced fracture of proximal humerus. To improve stability in osteoporotic humeral bones and to preserve the biological integrity of the humeral head and to secure an anatomical reduction with multiple locking screws with angular stability. Fixation must be stable enough to allow early motion & minimize the wound complications. X ray of the shoulder joint (AP & Lateral and Y-view) was assessed thoroughly and graded according to the fracture classification. Plan and determine proper plate positioning or if necessary, plan for soft tissue suturing using parachute technique.

Surgical technique: Positioning the patient supine on a fracture table with the head end angled at 30-45° and a sandbag placed behind the operating scapula, a deltopectoral or deltoid-splitting approach is employed.

Deltopectoral approach:[9] To locate the deltopectoral groove percutaneously, abduction and external rotation of the shoulder are performed in obese patients, with pressure applied behind the scapula. Starting at the coracoid process, the incision extends distally along the deltopectoral groove to the deltoid insertion for approximately 15 cm. Skin flaps are developed to expose the deep fascia, followed by opening the fascia over the deltopectoral groove with blunt scissors while identifying the cephalic vein. This vein serves as a landmark for identifying the avascular interval between the deltoid and pectoralis major muscles, which is bluntly developed. The deltoid is retracted laterally, and the pectoralis major is retracted medially, with the vein either ligated or retracted with the deltoid. The anterior circumflex artery lies in the middle of the wound, just superior to the pectoralis major muscle, and may require isolation, clamping, and coagulation. Wider exposure is achievable by transecting the muscle origins from the coracoid, and more proximal exposure may necessitate transecting the origin of the pectoralis minor muscle, while leaving a cuff on the tip of the coracoid for repair. Meticulous dissection of tendino-osseous attachments is recommended to avoid devascularization of the fracture fragment. The osseous attachments of the rotator cuff are pulled together to reduce the fracture. If reduction is challenging, a K-wire can be inserted as a joystick in the humeral head to aid in rotation, or sutures can be placed under the rotator cuff tendon (supraspinatus) for mobilization and reduction. For 3-part or 4-part fractures or osteoporotic fragments, sutures can be placed into the rotator cuff tendons attached to fractured fragments to assist in reduction. The plate is placed onto the greater tuberosity just posterior to the biceps tendon and temporarily fixed with Kirschner wires. Correct plate position is confirmed with a C-arm in both AP views in adduction and abduction. If the plate is placed too proximally, it may cause impingement, while placement too close to the biceps tendon may damage the anterior humeral circumflex artery. For plating, the plate is positioned at least 8 mm distal to the tip of the greater tubercle and fixed to the humeral shaft with screws. In cases of fractures with medial comminution, the plate is first fixed to the head with screws, and the shaft segment is then reduced to the plate to avoid varus malposition, which is associated with higher failure rates. Screw insertion into the inferomedial humeral head adds stability for fractures without medial calcar support. Confirmation with a C-arm in anteroposterior and lateral views is necessary for reduction and screw placement.

Post operative management- Postoperatively, the arm was placed in a sling for immobilization, and the drain was removed on the second postoperative day. The initiation of shoulder rehabilitation was determined based on the stability of fixation, quality of bone, and patient compliance. Passive range of motion (ROM) exercises, including pendulum movements, passive forward elevation, and external rotation, typically commenced on the first postoperative day if a stable reduction was achieved. Active ROM exercises for the elbow, wrist, and hand were also initiated immediately after surgery. Patients progressed through a three-phase rehabilitation program, starting with passive assisted exercises early on, followed by active exercises around 6 weeks postoperatively, and then transitioning to strengthening or resisted exercises at 10 to 12 weeks after surgery. Early passive assisted exercises aimed to prevent adhesion formation, and there were no restrictions on exercises within the pain-free ROM during this period, provided that bone stock was adequate and medial buttressing was sufficient. Shoulder strengthening and resistance exercises were introduced only after confirming bony consolidation on plain radiographs and ensuring adequate coordination of the extremity. Standard AP, scapular Y and axillary radiographic views were taken immediately after surgery, with routine follow-up radiographs scheduled at 3, 6 weeks, and 3, 6, and 12 months postoperatively to monitor pin migration, loss of reduction, evidence of callus formation, and fracture consolidation.[10,11]

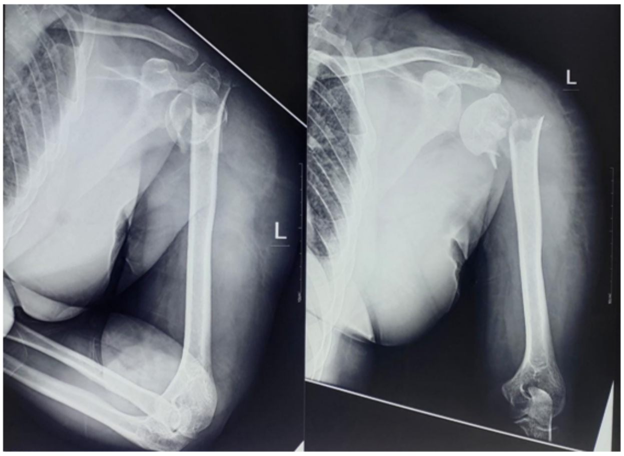


Figure 1: Pre-op x-ray – case 1

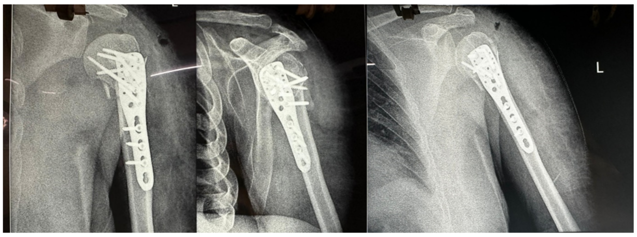


Figure 2: Post-op x-ray

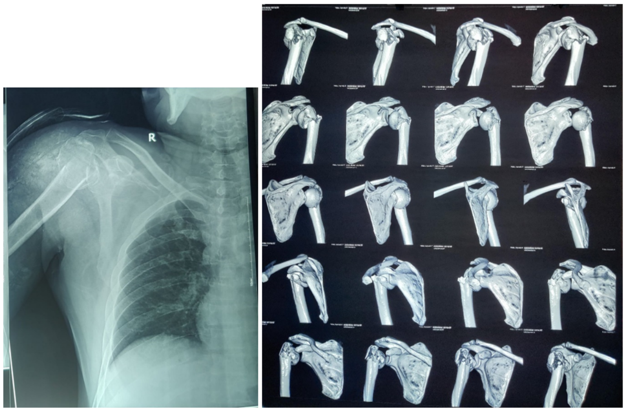


Figure 3: Pre-opx-ray – case 2

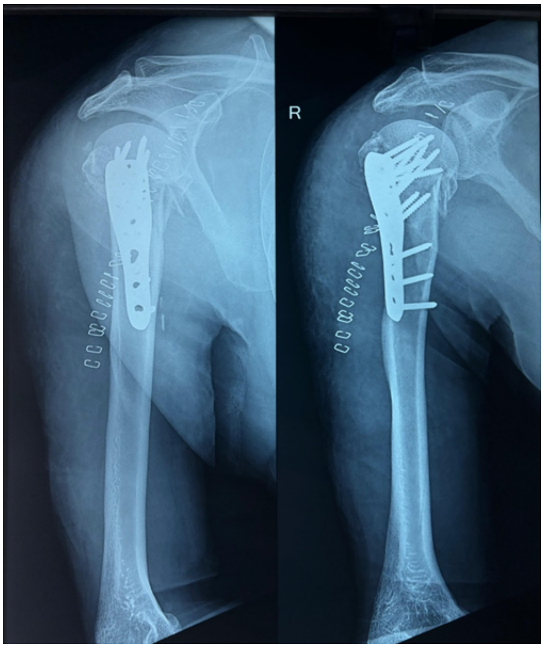


Figure 4: Post-op x-ray

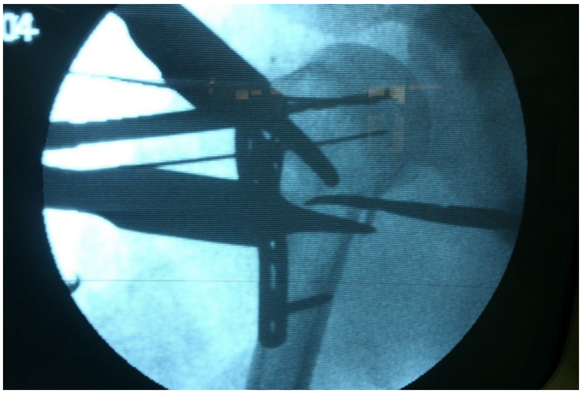


Figure 5: Intra-op C-arm image showing fracture reduction using k-wire and plate positioning

Figure 6: Final construct with plate and screw in position

Figure 7: C-arm image of final construct

4. Evaluation of Functional Outcome

At each follow-up appointment, patients underwent a comprehensive evaluation, including both clinical and radiological assessments. A comprehensive physical examination was conducted to assess shoulder function and mobility, and the Constant score was determined to assess functional status. Additionally, radiograph images of the proximal part of humerus were taken and evaluation done for evidence of bony healing, malunion, nonunion, or avascular necrosis, allowing for close monitoring of the healing process and detection of any potential complications. The Constant score is a comprehensive assessment aid utilized for evaluating shoulder function and mobility by assigning points in four categories: Range of motions, Pain, Power, and Activities of daily living. To assess muscle strength, a specific protocol was followed, as told by Constant. This encompassed assessing the patient's capacity to hold a 1 kg weight in their hand with their shoulder positioned in 90° of abduction. If achieving 90° abduction was not feasible, the assessment was conducted in maximum active abduction.[12]

5. Results

After analysing the above characters, 25% (5 individuals) achieved an excellent outcome, while 30% (6 individuals) had a good outcome. A moderate outcome was observed in 30% (6 individuals), and 15% (3 individuals) experienced a poorer outcome. Union was determined by the presence of a bridging callus on the follow up radiographs and by the clinical impression of stability. The mean Constant score was 70.25 points, with a range from 38 to 92 points. Specifically, the mean Constant score for Neer two-part fractures was 83.5 points (ranging from 70 to 92), for Neer's three-part fractures it was 74.75 points (ranging from 57 to 91), and for Neer's four-part fractures it was 59.13 points (ranging from 40 to 86).

The mean Constant score for the middle age group (18-40) was 83.2 points (range 68 - 92) with a standard deviation of 10.99. For the old age group (41-60) it was 67.5 points (range 40 - 91) with a standard deviation of 16.60. Lastly, for the very old age group (>60), the mean Constant score was 59.67 points (range 38-81) with a standard deviation of 21.50.

Eighteen out of the twenty patients achieved union at approximately 9 weeks of follow-up, accounting for 90% of the total cases. The exceptions were 2 cases those complicated by osteonecrosis. In one case with a four-part fracture, there was screw cut out. Although the patient underwent implant removal, follow-up radiological assessments revealed evidence of successful union, therefore no additional surgical interventions were necessary.

6. Discussion

Treating complex humeral fractures, particularly those with three or four parts, requires a high degree of surgical expertise. The goal is to achieve precise alignment and stable fixation while minimizing the risk of complications, such as screw penetration and avascular necrosis of the humeral head. To accomplish this, surgeons must take great care to protect the surrounding soft tissues and avoid damaging them, which is crucial for optimal recovery and functional outcomes.

Poor outcomes in complex fractures like these can be attributed to several factors:

1. Inadequate fracture reduction, particularly involving the medial cortex.
2. Unstable fixation of the fracture.
3. Incorrect positioning of the fixation devices.

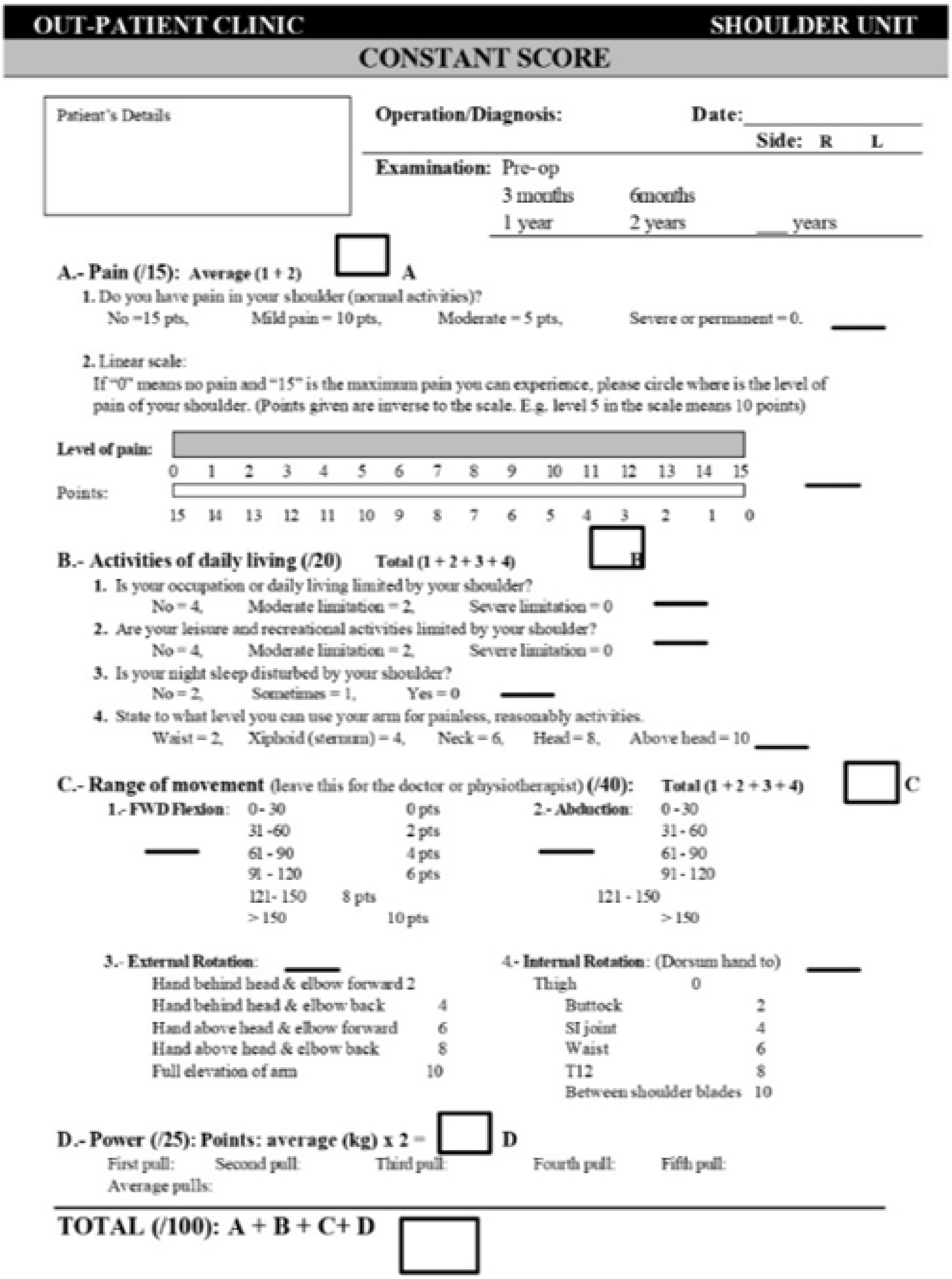
The literature agrees that achieving a good functional outcome in humeral fracture treatment relies primarily on two key factors: anatomical fracture site reduction and stable fixation. Additionally, early initiating functional rehab of the shoulder is crucial. However, this study reveals that three specific factors - patient age, minimal fragmentation of the fracture part, and eager fixation of the fracture - have a direct positive impact on functional outcomes, suggesting that these factors can influence the success of treatment.

In recent years, there has been a noticeable trend towards employing rigid internal fixation in the surgical management of proximal humeral fractures. This approach has gained significant popularity in the operative treatment of these fractures. Despite prompt and secure functional post-op therapy, there was an expectation that these implants could reduce the risk of secondary loss of reduction in patients with osteoporosis. In elderly individuals with osteoporosis, traditional plate osteosynthesis often yields unsatisfactory functional outcomes. To address this challenge and achieve more consistent and improved results, the AO/ASIF developed the Philos locking compression plate, a specialized implant designed specifically for fractures involving proximal humerus.[13] Patients with optimal bone quality have typically achieved positive outcomes with traditional plate osteosynthesis treatment.[14]

In this study, the majority of patients (12 out of 20) belonged to the age group of 41-60 years, a demographic highly susceptible to osteoporosis.

Conventional plates have limitations when used in osteoporotic bone, as the screws are more likely to back out or cut out, leading to inadequate fragment fixation. The fragile nature of osteoporotic bone makes it challenging to achieve proper reduction, and traditional screws are prone to soft tissue disruption, resulting in a higher risk of procedure failure.

Poor	(0 - 55 points),
Moderate	(56 - 70 points),
Good	(71 - 85 points),
Excellent	(86 - 100 points).


OUT-PATIENT CLINIC SHOULDER UNIT

CONSTANT SCORE

Patient's Details

Operation/Diagnosis: Date:

Side: R L

Examination: Pre-op
3 months 6months
1 year 2 years ___ years

A.- Pain (/15): Average (1 + 2) A

1. Do you have pain in your shoulder (normal activities)?
No =15 pts, Mild pain = 10 pts, Moderate = 5 pts, Severe or permanent = 0.

2. Linear scale:
If "0" means no pain and "15" is the maximum pain you can experience, please circle where is the level of pain of your shoulder. (Points given are inverse to the scale. E.g. level 5 in the scale means 10 points)

Level of pain: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Points: 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

B.- Activities of daily living (/20) Total (1 + 2 + 3 + 4) B

1. Is your occupation or daily living limited by your shoulder?
No = 4, Moderate limitation = 2, Severe limitation = 0
2. Are your leisure and recreational activities limited by your shoulder?
No = 4, Moderate limitation = 2, Severe limitation = 0
3. Is your night sleep disturbed by your shoulder?
No = 2, Sometimes = 1, Yes = 0
4. State to what level you can use your arm for painless, reasonably activities.
Waist = 2, Xiphoid (sternum) = 4, Neck = 6, Head = 8, Above head = 10

C.- Range of movement (leave this for the doctor or physiotherapist) (/40): Total (1 + 2 + 3 + 4) C

1.- FWD Flexion: 0 - 30 0 pts; 31 - 60 2 pts; 61 - 90 4 pts; 91 - 120 6 pts; 121 - 150 8 pts; > 150 10 pts

2.- Abduction: 0 - 30; 31 - 60; 61 - 90; 91 - 120; 121 - 150; > 150

3.- External Rotation:
Hand behind head & elbow forward 2
Hand behind head & elbow back 4
Hand above head & elbow forward 6
Hand above head & elbow back 8
Full elevation of arm 10

4.- Internal Rotation: (Dorsum hand to)
Thigh 0
Buttock 2
SI joint 4
Waist 6
T12 8
Between shoulder blades 10

D.- Power (/25): Points: average (kg) x 2 = D
First pull: Second pull: Third pull: Fourth pull: Fifth pull:
Average pulls:

TOTAL (/100): A + B + C + D

Figure 8: The constant score grading

Table 1: Functional scores achieved with various treatment modalities for proximal humeral fractures in the existing literature

Available Study	Type of fixation	Constant score	Neer's classification
Kuchle et al (2006)[15]	Cloverleaf plate	72.4	2,3& 4 part fracture
Lill et al (2003)[16]	Angle stable humerus plate	72.5	2,3&4 part fracture
Kollig et al (2003)[17]	T plate, screws & k wires	72.1	3 & 4 part fracture
Wijgman et al (2002)[14]	Classic T Plate cerclage	80.0	3 & 4 part fracture
Gerber et al (2004)[18]	Internal fixation	78	2,3,& 4 part fracture
Hessman et al (2003)[19]	T plate	69	2,3,& 4 part fracture
Our study	Locking plate	70.25	2,3,& 4 part fracture

The introduction of locking plates has significantly reduced the incidence of screw backout or cutoff, thanks to the lockable head and fixed angle design of the screws. Additionally, the multi-direction nature of the screws in locking plates, which engage with the spherical head of the humerus, provides enhanced stability and reducing the risk of fixation failure and humeral head collapse. Locking plates offer the advantage of tendon suturing through plate eyelets, facilitating secure fixation of small osteoporotic bone fragments, which was previously challenging. This feature also minimizes the fear of collapse. While rates of soft tissue dissection are comparable between conventional and locking plates, skilled surgical methods and meticulous procedures can mitigate this issue. Furthermore, locking plates exhibit reduced compression at the bone-plate interface in contrast to conventional plating, which helps preserve blood flow to the bony part and humeral head, reducing avascularity and promoting healing.

The average clinical outcome achieved in our study, with a mean Constant-Murley score of 70.25 points, is deemed satisfactory.

Research comparing internal fixation methods for fractures involving proximal humerus has yielded similar short-term outcomes. While our study's follow-up period was brief, existing literature suggests that early functional results are often indicative of long-term outcomes. The final outcome is influenced by various factors, including fracture severity, quality of anatomic reduction, etiology, bone density, time elapsed between injury and surgery, presence of accompanying injuries, and the precise placement and implant fixation.[20]

Achieving accurate anatomical reduction and precise plate placement are critical for optimal outcomes. Research indicates that when anatomical reconstruction is attained and the plate is positioned correctly on the shaft to avoid subacromial impingement, patients tend to have significantly higher Constant-Murley scores, reflecting better functional outcomes. Conversely, inadequate anatomical reconstruction or acceptance of non-anatomical reduction intraoperatively, and/or incorrect plate positioning, resulted in significantly lower Constant-Murley scores (indicating poorer function).

In our study, three cases (15%) resulted in poor outcome scores. These included two instance of osteonecrosis of the humeral head may be due to delayed surgical intervention, one case screw cut out. Notably, there were no significant differences in outcomes observed in cases of screw perforation into the joint or chronic infection.

The occurrence of aseptic humeral head necrosis (2 patients or 10%) significantly impacted clinical outcomes, with these patients achieving a mean Constant-Murley score of 39. It's worth noting that in the literature, the rate of necrosis for three- and four-part fractures has varied between 0% and 50%, depending on the osteosynthesis procedure employed. The 10% rate of aseptic necrosis observed in our study aligns with existing literature and is deemed acceptable.

7. Conclusion

Despite the limitations of our study, including its relatively short duration and non-randomized design, our findings align with published research in the field. Notably, accurate anatomical reduction and timely fracture fixation emerge as crucial factors in achieving optimal functional outcomes, superseding the specific implant used. This key takeaway is independent of implant design and surgical approach, highlighting the primacy of precise reduction and early fixation in driving successful patient outcomes.

The choice of surgical approach and implant type depends on various factors, including the fracture pattern, bone quality, patient goals, and the surgeon's expertise and comfort with specific techniques. Additionally, the learning curve associated with the chosen implant plays a significant role. A skilled surgical technique will help minimize complications, while a rigorous rehabilitation program will ensure optimal outcomes. The combination of these factors will ultimately determine the success of the procedure.

The functional outcomes for fractures with 2, 3, or 4 parts treated with locking plates are comparable, with all groups achieving satisfactory results. Typically, open reduction and internal fixation with a plate and screws is a suitable treatment approach for 2- and 3-part fractures. Moreover, younger patients with 4-part fractures can also benefit from this treatment approach, leading to successful functional outcomes.

8. Source of Funding

None.

9. Conflict of Interest

None.

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