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# A study on the functional and radiological outcome with complications in the management of proximal humerus fractures operated with proximal humerus internal locking osteosynthesis system

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## ABSTRACT

**Background:** A number of opinions exist regarding the management of proximal humerus fractures starting from conservative to tension band-wiring to internal fixation with plates. The aim of this study is to assess the functional outcome, the radiological outcome and the complications associated with the management of proximal humerus fractures treated with proximal humerus interlocking osteosynthesis system (PHILOS).
**Methods:** A prospective descriptive study was undertaken comprising of 40 patients. Closed proximal humerus fractures meeting Neer's criteria for operative displacement were enrolled. Patients underwent open reduction internal fixation with PHILOS plate. Post-operative radiological outcome was estimated with follow-up x-rays, functional outcome using the Constant and Murley score.
**Results:** 60% patients were female, with the most common mode of injury being fall at a ground level. Late complications were noted in 25% of patients, which were malunion 5%, joint stiffness 10%, joint instability 5% and heterotopic ossification 5%. The mean Constant and Murley score was 79.5 and it was found to be statistically significant to the type of fracture according to the Neer's classification (Kruskal Wallis test, p=0.005). Joint stiffness was also found to be statistically significantly correlated to the type of fracture pattern (Chi square test, p=0.016). The average time to union was 10 weeks.
**Conclusions:** Thus, by this study it can be expressed due to appropriate articular reduction by open reduction and by the use of a fixed angle implant like the PHILOS plate, operative management of proximal humerus fractures by the said implant is a viable option to enable quick and early rehabilitation of patients.

**Keywords**: Proximal humerus fracture, Proximal humerus interlocking osteosynthesis system, Constant and Murley score

## INTRODUCTION

Proximal humeral fractures account for about 4 to 5% of all fractures.[1,2] It accounts for up to 45% of all humeral fractures.[3] It is the third most common fracture in the elderly.[4] Numerous authors have suggested that non operative treatment can be acceptable for two, three and four part fractures of proximal humerus in elderly patients but pain, stiffness, loss of function and muscle power have been described in more percentage of patients following this conservative approach.[5-7] Conservative approaches also increase the time-period after which the patient is able to return to normal activity and thus increase the disease burden on the patient. Proximal humerus fractures

traditionally were fixed with K-wires, tension band wiring and using Ender's nail in case of significant displacement of the shaft.[8,9] Thus, the treatment of proximal humerus fractures remain controversial with the varied techniques described in literature. However, with the onset of the PHILOS plates (Proximal Humerus Internal Locking Osteosynthesis System), fixation of proximal humerus fractures has been standardised as it has shown high primary stability and good results.[1,10-13] Emphasis is placed on complete and accurate diagnosis and formulation of safe and simple standard techniques for fracture realignment, restoration of anatomic stability, fracture healing, cuff integrity, regaining movement and function. The elderly people no longer need to be denied effective surgical treatment, especially at a time in life, when the shoulders are often needed for ambulation with canes and crutches, keeping this in mind the current study was undertaken. Maintenance of good shoulder function will surely make an appreciable difference to their independent life style. The primary objective of this study is to analyse the functional outcome and radiological outcome of forty cases of proximal humeral fractures treated surgically using PHILOS plates (proximal humerus internal locking osteosynthesis system). The secondary objective of this study is to analyse the rate of complication regarding the same.

## METHODS

A prospective descriptive study was undertaken at R.G. Kar Medical College, Kolkata, India, during the study period May 2020 to June 2022 after acquiring ethical committee approval. Sample size was calculated based on previous studies conducted in literature, and after including a 20% attrition rate, 43 patients were selected for the study out of which 3 patients dropped out. Since this was a time bound single centre study with no financial funding, a non-random convenience sampling technique was chosen.[14,15] Samples were selected from the patients admitted in the inpatient and visiting the outpatient department of the Department of Orthopaedics, R.G. Kar Medical College. Inclusion Criteria was all patients with proximal humerus fractures, who are skeletally mature and age more than 18 years and satisfy Neer's criteria for operative displacement i.e., displacement of >1 cm between the major fracture fragments or angulation of the articular surface of >45 degrees. Also Neer's two, three and four part fractures were included.[10,11] Patients with open fractures and associated neurovascular and/or head injury were excluded. After pre-operative assessment, radiographs of the affected shoulder were taken in AP, Lateral and Axillary views and fractures were classified according to Neer's classification.[10,11] CT pictures were taken in selected patients with complex fracture patterns to know the articular involvement. All patients were positioned supine on the table with a sand bag between the spine and medial border of the scapula in order to push the affected side forward and to open up the front of the joint. Thirty-two patients were operated using standard delto-pectoral approach. Eight patients were operated using deltoid splitting approach. There was no conversion from a deltoid splitting approach to a delto-pectoral approach. The fragments were reduced indirectly and temporarily fixed with the help of 1.5 or 1.8 mm K wires under image intensifier control. After obtaining acceptable reduction, the PHILOS plate was placed at least 8mm distal to the upper end of the greater tuberosity to prevent sub-acromial impingement. The long head of biceps tendon was identified and preserved. The plate was then placed lateral to the long head of biceps without compromising its function. The shoulder was checked for stability of fixation, range of movements and absence of impingement. None of our patients required bone grafting. X rays are taken in the immediate post-operative period to document the fracture alignment, reduction and fixation. X rays are repeated to monitor the post op radiological outcome by monitoring the fracture union and to quality of reduction, restoration of articular congruity, PHILOS plate deviation, screw back out, implant loosening and failure. Mal-union was defined as healing of the fracture with a neck/shaft angle of less than 120° or more than 145° on an antero-posterior radiograph. The patients were followed up at regular intervals every two weeks during the first 3 months and every 1 month thereafter. Post op functional outcome was assessed by using Constant and Murley Score (CMS).[12] The European Society for Shoulder and Elbow Surgery (ESSES) adopted the scoring system of Constant and A Murley. This scoring system consists of four variables that are used to assess the function of the shoulder. The subjective variables are pain=15 and activities of daily living=20 (sleep, work, recreation/sport) which give a total of 35 points. The objective variables are Range of Motion=40 and Strength = 25 which give a total of 65 points. Phase I post-operative rehabilitation exercises consisting of pendulum exercises were started from the first week. Gentle passive forward flexion, internal and external rotation exercises were initiated by third week. Phase II exercises consisting of active range of motion exercises and resistive exercises were started by 4-6 weeks. Phase III exercises consisting of advanced stretching and strengthening exercises were started by 3 months. Lifting of light weight objects were started after 3 months. All data was collected, compiled and subjected to suitable statistical analysis using appropriate methods. Also, informed consent was undertaken by all the patients participating in the study. The IBM SPSS 25 was used for data analysis and MS Excel 2016 was used for data entry and grand chart creation. Results were discussed on the background of present knowledge & experience of past work.

## RESULTS

Of the 43 patients selected for the study 24 (60.0%) patients were females and 16 (40.0%) patients were male, 3 patients dropped out of the study. Proximal humerus fractures were overall more common among the 51-60 age group patients with a 35.0% prevalence (Table 1). Mean age was 47.90 (SD=11.82) with the minimum age being 20 years and maximum age being 65 years.

The most common mode of injury was fall at ground level (50.0%) followed by road traffic accident (30.0%). No bilateral fractures were reported in our study. 75% patients had injury to their dominant arm. Mean time for arrival after injury was 6.60 days (SD=2.55) and 10 patients had previous treatment either in the form of indigenous splinting or plaster of Paris application. Based on Neer's system 24 patients (60.0%) had two part fractures, 14 (35.0%) had 3 part fractures and 2 (5.0%) had four part fractures.

**Table 1: Age distribution.**

| Age group (years) | N | % | Males | Females |
|---|---|---|---|---|
| **15-20** | 2 | 5 | 2 | 0 |
| **21-30** | 4 | 10 | 4 | 0 |
| **31-40** | 4 | 10 | 2 | 2 |
| **41-50** | 10 | 25 | 4 | 8 |
| **51-60** | 14 | 35 | 2 | 10 |
| **>61** | 6 | 15 | 2 | 4 |

Fracture dislocations were present in 4 (10.0%) patients. The minimum follow-up period was six months and maximum follow up period was 8 months (Mean 6.80 months SD =0.82). Early complications were noted in 6 (15.0%) patients, of which 2 were wound gaping due to Type 2 Diabetes Mellitus which resolved with re-suturing. 2 patients with 3-part fracture developed skin necrosis due to extensive soft tissue handling which resolved by intravenous antibiotics. 2 patients had deltoid atony after surgery which improved with sling and physiotherapy. A number of late complications developed in 10 (25.0%) patients.

**Table 2: Comparison of fracture pattern to the functional outcome.**

| Neer's type | N | Mean Constant and Murley Score (SD) | Kruskal Wallis H Statistic (df) | P value |
|---|---|---|---|---|
| **2** | 24 | 81.17 (17.70) | 10.77 (2) | 0.005 |
| **3** | 14 | 78.0 (5.43) | | |
| **4** | 2 | 70.0 (0.0) | | |

Post-hoc analysis with Bonferroni corrections shows significant difference between type 2 fractures and type 3 fractures (p=0.032) and between type 2 and type 4 fractures (p=0.042).

Malunion occurred in 2 patients (5.0%), joint stiffness in 4 patients (10.0%), joint instability in 2 patients (5.0%), heterotopic ossification in 2 patients (5.0%). No case of non-union, avascular necrosis or chronic osteomyelitis was detected in this study. Functional outcome was measured by the Constant and Murley Score (12) as it has been accurately reproducible by several observers and at the same time it can detect even small changes in function. 22 (55.0%) patients said that they had no pain and 12 (30.0%) patients had only mild pain, 6 (15.0%) patients had pain of moderate intensity. No patient had severe pain in follow-up. 12(30.0%) patients had an activity of daily living score above 30, 20(50.0%) had above 25, 6 (15.0%) had above 20 and 2 (5.0%) had an activity of daily living score below 15. When it came to range of motion, the mean abduction achieved was 125.75°(SD=22.08), mean flexion was 96.00° (SD=9.55), mean extension was 45.00° (SD=6.40), mean external rotation was 48.25° (SD=6.05), average internal rotation was end of thumb to T11 spinous process.

**Table 3: Comparison of approach to the functional outcome.**

| Approach | N | Mean Constant and Murley Score (SD) | Mann Whitney U Statistic (df) | P value |
|---|---|---|---|---|
| **Delto-Pectoral** | 32 | 80.63 (15.40) | 52.0 (1) | 0.009 |
| **Deltoid Split** | 8 | 75.0 (6.50) | | |

**Table 4: Association between fracture type to joint stiffness.**

| Neer's Type | Joint Stiffness | | Total | $\chi^2$-statistic (df) | P Value |
|---|---|---|---|---|---|
| | No, N (%) | Yes, N (%) | | | |
| **2** | 24 (60) | 0 (0) | 24 | 8.254 (2) | 0.016 |
| **3** | 10 (25) | 4 (10) | 14 | | |
| **4** | 2 (5) | 0 (0) | 2 | | |

When it came to muscle strength 34 (85.0%) of the patients could maintain 90 degrees of elevation of the pronated hand in the scapular plane for 5 seconds, three times with a 12 kg weight scoring 25 points. 4 (10.0%) patients could do it with 8 kg weight scoring 15 points. 2 (5.0%) could do it pain free with only 1 kg scoring 3 points. Overall results of the Constant and Murley Score Are Excellent (86-100) in 13 patients (32.5%), Good (71-85) in 22 patients (55.0%), Moderate (56-70) in 4 patients (10.0%), Poor (0-55) in 1 patient (2.5%). The mean Constant and Murley score is 79.50 (SD=14.20). Radiologically there were no cases of non-union due to the highly vascular nature of the metaphyseal area. There were two cases (5.0%) of malunion, which encases the efficiency of open reduction and internal fixation with a fixed angle implant. The average time to union was 10 weeks. When the type of Neer's fracture was compared with the Constant and Murley score, a non-Gaussian distribution was found, so a Kruskal Wallis H test was used, which was found to be statistically significant (Table 2). This signifies the severity of the initial injury plays a major role in the final functional outcome of the patient. When type of approach used was compared to the Constant and Murley score using a Mann Whitney U test, the difference was found to be statistically significant (Table 3). Thus, a deltoid sparing approach that is the delto-pectoral approach, preserves the muscle body, offering a better final outcome.

**Table 5: Comparison of Constant and Murley score.**

| Constant & Murley Score | This study (%) | Bjorkenheim et al[16] (%) | Martinez et al[20] (%) | Aggarwal et al[17] (%) | Erasmo et al[23] (%) |
|---|---|---|---|---|---|
| **Excellent (86-100)** | 32.5 | 5.55 | 22 | 17 | 9.75 |
| **Good (71-85)** | 55.0 | 44.44 | 62 | 38.5 | 63.4 |
| **Moderate (56-70)** | 10.0 | 43.05 | 14 | 34 | 20.7 |
| **Poor (0-55)** | 2.5 | 6.94 | 2 | 10.5 | 6.0 |

However, age was not significantly correlated to the Constant and Murley score. When the type of fracture was compared to the late complications, only joint stiffness was found to be significantly correlated by the Chi-Square test (Table 4). So, an initially severe injury regardless of the fixation, can contribute to loss of function of the shoulder joint in time. This study was not funded and did not have any conflict of interest.

## DISCUSSION

Proximal humerus fractures previously were fixed with K-wires, tension band wiring and using Ender's nail in case of significant displacement of the shaft or were managed conservatively.[5-12] Hawkins et al did a retrospective study on 15 patients and demonstrated the effective use of tension band-wiring technique in the fixation of 3 part proximal humerus fractures.[13] Cuomo et al did a study where eighteen (82%) of the 22 patients had good or excellent results with the said technique. However, with the onset of the PHILOS plates, fixation of proximal humerus fractures has been standardised as it has shown high stability and quick return to daily activities (1, 10-13).[14,15] The primary objective of our study is to show the functional and radiological outcome in the management of proximal humerus fractures with PHILOS plates. As a secondary objective the complications of the said implant were also estimated. When it came to the demographic data of the 43 patients selected for the study 24 (60.0%) patients were females and this female prevalence is similar to Bjorkenheim et al study at 61%.[16] Proximal humerus fractures were overall more common among the 51-60 age group patients with a 35.0% prevalence (Table 1). This suggests a correlation to osteoporosis and a similar outcome was noticed in Aggarwal et al study as well.[17] Osteoporosis is a common occurrence in post-menopausal females and such demographic prevalence is reflected in our study. PHILOS plate is specifically designed for osteoporotic fractures as it has multiple screws which are oriented at different but fixed angles. This provides optimal fixation at different planes which is necessary in osteoporotic bone. The most common mode of injury was fall at ground level (50.0%) while 75% patients had injury to their dominant arm. In Charalambous et al study 60% patients had fractures in the dominant arm with 68% due to body height fall.[18] So it can be stated that proximal humerus fractures are usually low velocity injuries which are often found in osteoporotic bones. Early complications were noted in 6 (15.0%) patients which is comparable to Egol et al study 24% patients developed early complications.[19] However, in our study all of the early complications were resolved by early diagnosis and quick interventions. When it came to late complications, malunion occurred in 2 patients (5.0%), this is different from Charalambous et al study where almost 18% patients developed mal-union.[18,19] Charalambous et al performed 25 PHILOS fixation and had a median follow-up of 6 months, of which 20 underwent union. Martinez et al conducted a study on 58 patients who were treated with the same implant and among them only 1.7% cases of mal-union were found.[20] In our study, post-operative rehabilitation protocols were rigorously followed and in particular cases physiotherapists were assigned to the patients for in-home rehabilitation. Delayed weight lifting at 3 months could have contributed to the low incidence of mal-union in our study. No case of non-union, avascular necrosis or chronic osteomyelitis were detected in this study. However, this study did have the limitation of having a limited sample size and a relatively short period of follow-up to accurately reflect upon the entire population as a whole. The standard delto-pectoral approach usually jeopardises the anterior circumflex humeral artery, which is the main supply of the humeral head as demonstrated by cadaver studies.[21,22] But in our study, we took extensive care to use a smaller incision, avoid placement of large retractors and use indirect reduction techniques such as K-wires with fluoroscopy in order to preserve the anterior circumflex humeral artery, which when de-vascularised gives rise to avascular necrosis. Erasmo et al did a study on 82 cases of proximal humerus fractures treated with PHILOS plating over a period of 4 years and found that 12% cases under went avascular necrosis.[23] Non-union was also a frequent complication in most studies like Bjorkenheim et al study where 2.7% of fractures developed non-union, Charalambous et al study which had 12% non-union, Egol et al study where 7.8% cases developed non-union, Rose et al study had 25% non-union.[16-20,23,24] 3.9% cases developed implant failure in Egol et al study which comprised of 51 cases of proximal humerus fractures, while none occurred in this study.[19] Functional outcome was measured by the Constant and Murley Score.[20] The mean Constant and Murley score is 79.50 (SD=14.20), which is similar to Martinez et al study = 80, Fazal et al study=70, Koukakis et al study=76.1, Acklin et al study=78, Erasmo et al study=75. Oldrini et al, meta-analysis of 39 studies gave a mean CMS score of 70.8.[14,23-27] Oldrini et al meta-analysis comprised of 78 articles, and it was undertaken to quantify the rate of complications and re- interventions in patients treated with PHILOS plate for

proximal humerus fractures.[27] According to the Oldrini et al meta-analysis, functional outcomes were excellent in 3 studies (7.7%), good in 21 (53.8%), moderate in 13 studies (33.4%), and poor in 2 studies (5.1%). This was similar in our study where 55.0% patients had a good CMS score.[27] The different functional outcomes of our study to other studies are enumerated in (Table 5).

When the type of Neer's fracture was compared with the Constant and Murley score, a non-Gaussian distribution was found, so a Kruskal Wallis H test was used, which was found to be statistically significant (Table 4). Similar results were obtained in the Bjorkenheim et al and Aggarwal et al study.[16,17] So this encases the fact that with the increase of the nature of the complexity of the fracture which is usually determined by the type of injury, the functional outcome of the patient deteriorates. Also, type 4 fractures especially in osteoporotic can be notoriously comminuted, which can often lead to aggressive tissue handling while striving for a proper articular reduction. This in turn leads to increased operative time, tissue fibrosis and loss of vascularity of the fracture fragments, which can result in poor functional outcome in the patient. In our study we found that using a delto-pectoral approach offered a statistically significant better Constant and Murley score than using a deltoid split technique, and similar results were found in Singh et al study.[28] This could be due to maintaining the integrity of the deltoid fibers while opting for a delto-pectoral approach. However, age was not significantly correlated to the Constant and Murley score which is similar to Koukakis et al and Kettler et al study, unlike the Bjorkenheim et al and Aggarwal et al study where increasing age was found to be statistically significant to the decreasing CMS.[4,16,17,28] Radiologically there were no cases of non-union due to the highly vascular nature of the metaphyseal area, similar to Aggarwal et al study.[17] There were two cases (5.0%) of malunion, which encases the efficiency of open reduction and internal fixation with a fixed angle implant. The average time to union was 10 weeks. Similar results were found by Egol et al at 12 weeks, Aliuddin et al at 8.31 weeks.[17,19,29] This time was 20 weeks in Aggarwal et al's study (17). This is in contrast to conservative management, but at the same time it can be argued that lesser complications tend to occur in fractures treated by conservative approach.

### *Limitations*

Limitations of this study are the small sample size, and it being a single center study within a short time frame, the results might be difficult to implement in the broader population. As a descriptive study, with no comparative analysis with other modalities of management of proximal humerus fracture, definite superiority of one over the other cannot be stated.

## CONCLUSION

Proximal humerus fractures can be difficult to treat, especially in the elderly where they can result in significant morbidity in the fact that they can result in loss of independence and decrease in activities of daily living. As shown by the study, PHILOS plate can decrease the period of inactivity, provide opportunity for early mobilisation, at the same time can help in early union of the fracture as it provides angular stability and can maintain the reduction post-operatively. Thus, it can be stated that with fewer complication rate and good functional outcome, PHILOS plate is an effective and recommended implant for the management of proximal humerus fractures.

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