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Proximal humerus locking plate fixation for proximal humerus fractures

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Abstract
Objective: To evaluate functional outcome and complications of open reduction and internal fixation with proximal humeral internal locking system (PHILOS) plate for proximal Humerus fractures.
Methods: We reviewed 20 patients who underwent open reduction and internal fixation with PHILOS plate from June 2012 to June 2013. There were 16 men and 4 women with a mean age of 45.01 years (range 41-50). There were 9 patients in the age group of <40 years and 11 patients in the age group of >40 years. According to Neer classification system, 7, 12 and 1 patients had 2-part, 3-part, and 4-part fractures, respectively. All surgeries were carried out at tertiary care Hospital. Functional evaluation of the shoulder at final follow-up was done using Constant score.
Results: The mean follow-up period was 18 months (range 12-36 months). Three patients were lost to follow-up. Of the remaining 20 patients, all fractures were united clinically and radiologically. The mean time for radiological union was 90 days {12 weeks (range 8-20 weeks)}. At the final follow-up the mean Constant score was 67.25 (range 50-100). The results were excellent in 7 patients, good in 7 patients, fair in 5 patients and poor in 1 patient. During the follow-up, one case of varus malunion, four cases of stiffness and five cases of abductor weakness were noted. No cases of avascular necrosis, hardware failure, locking screw loosening or non-union, failure of fixation were noted.
Conclusion: PHILOS provides stable fixation in proximal Humerus fractures. To prevent potential complications like avascular necrosis, meticulous surgical dissection to preserve vascularity of humeral head is necessary.

Keywords: Proximal humerus fracture, fracture fixation, internal, proximal humeral internal locking system (PHILOS)

Introduction
Proximal Humerus fractures account for approximately 5% of all fractures [2]. They are the most common upper limb fracture, trailing only the distal radius fracture and in patients older than 65 years. They are the third most common fracture overall following hip and distal radius fracture [1, 3-6]. High velocity trauma is the cause in younger patients and it may results in fracture dislocations, whereas trivial trauma can be the cause in older individuals because of osteoporosis. Most of these fractures are stable and minimally displaced and can be treated conservatively [8]. Various modalities of treatment are available for the treatment of proximal Humerus fractures, including closed reduction and percutaneous K-wire fixation, open reduction followed by fixation with bone sutures, tension band, circulating wire, T plate, intramedullary nails, or locking plates and prosthetic replacement [7, 9, 10, 12]. Several complications have been reported, such as cut-out or back-out of the screws and plates, nonunion, avascular necrosis (AVN), nail migration, and rotator cuff impingement syndrome [11, 14]. Proximal humeral internal locking System (PHILOS) has been developed to solve these complications, especially to improve fracture fixation in elderly osteoporotic bones. It minimizes soft tissue dissection and gives both axial and angular stability, hence, reducing the risk of fracture displacement. This study was carried out to evaluate functional outcome and complications following proximal Humerus fracture Fixation using PHILOS plate.

Methods
We reviewed 20 patients with proximal humerus fractures, who underwent open reduction and internal fixation with PHILOS plate. This study was approved by local ethics committee and informed written consent was taken from all patients.

Inclusion criteria were as follows

1. Any patient with two part, three part and selected four part fracture of proximal humerus**.**

Exclusion criteria included

1. Compound fractures of proximal humerus.
2. Patients having fractures in clavicle or any other part of humerus in same limb.
3. Patients with cervical spine injuries.
4. Complex four part proximal humerus fractures in elderly patients with less functional demand.

There were 16 men and 4 women with a mean age of 45.01 years (range 41-50). 17 patients were in the age group of <60 years and 3 patients were in the age group of >60 years. Fracture was caused by trivial fall in 6 patients, by assault in 2 patients and caused by road traffic accidents in the rest (12) of the patients {60% patients were having high velocity trauma and 40% patients were having low velocity trauma}. In our study, 35% patients were labourer, 25% were having sedentary work, 20% were house wives and other accounted for 20%. The mean trauma surgery interval in present study was 3.40 days. In our study, commonly associated medical illness was Hypertension (35%). In our study, left side of proximal humerus fracture (65%) was more common than right sided (35%).

Fractures were classified based on preoperative plain radiographs (Figure 1A). According to Neer classification system, 7, 12 and 1 patients had 2-part, 3-part, and 4-part fractures, respectively. Head splitting and impaction were noted in 3 and 2 patients respectively. CT scans were obtained from 12 patients (Figures 1B and C). All surgeries were carried out at our tertiary care Hospital under general anaesthesia in 2 patients and under brachial block in 18 patients with the patient in the beach chair position (head end of the table was elevated 35-45 degrees to the horizontal).

A small bump was placed behind the patient's back to turn the patient slightly to the opposite side with affected shoulder off the edge of the table. Trial fluoroscopic images were taken prior to scrubbing and draping. Imaging unit was placed towards the head end of the table. A deltopectoral approach was used. Skin was infiltrated with local anaesthetic. The incision was started midway between coracoid and clavicle, and extended distally up to deltoid insertion. Cephalic vein was identified and retracted laterally. Plane was developed between deltoid and pectoralis major. Conjoint tendon was identified and retracted medially. The long head of biceps is the important landmark as it signifies rotator interval. It was found to be torn in 2 cases. Tenodesis with pectoralis major was done towards the end of the procedure. Traction sutures were applied to tuberosity fragments using No.5 Ticron to hold and reduce fragments.

K-wires were used in humeral head as joysticks and fixed temporarily with the humeral shaft. PHILOS plate was placed about 5 to 10 mm distal to the tip of greater tuberosity (confirmed under image intensifier) and just lateral to bicipital groove. First a standard 3.5 mm cortical screw was placed in oval hole and tightened lightly. Fracture reduction and plate position were reconfirmed under image before placing other screws. Locking screws were placed in humeral head using drill guide. Drilling was done under sequential fluoroscopic imaging to prevent intraarticular penetration. Subchondral screw position was confirmed under two image views. Minimum of five head screws were used. Inferomedial oblique screw was unable to be put in four patients due to distal placement of the plate. Finally screws were placed in humeral shaft. Minimum of three bicortical screws were used in all patients.

Autogenous bone grafting was used in two cases. Tuberosity sutures were tied to the plate. Indications for the use of sutures should be generous as the added stability allowed for early postoperative exercises and decreased the risk of loss of reduction and malunion [13, 16]. Intraoperative fracture at the apex of the implant occurred in one case and was fixed with a dynamic compression plate (DCP, Figure 2). The wound was closed over a suction drain, which was removed after 24 to 48 hours postoperatively. The average operative time for proximal humerus plating was less than 2 hours. The average blood loss was 300cc-500cc. Patient who had trauma surgery interval more than 5 days had more intra operative blood loss. Patients who had longer operative duration had more blood loss. In our study, 55% patients had more than 2 hours of operating time. 16 patients (80%) had more than 300ml of blood loss. As per protocol all patients operated for proximal humerus in my institute were given minimum 1 unit of intra op blood transfusion. 3 patients were given 2 units of blood transfusion; they had more than 500 ml of blood loss, and more than 2 hours of operating time. No patient had any injury to neurovascular structure

Post-operatively, Arm was supported with a sling. In our study, 70% of patients were mobilized before 7 days in post-operative period. Pendulum along with passive forward flexion and external rotation was started from the first postoperative day followed by active assisted exercises after 3 weeks and active exercises after 6 weeks. Strengthening exercises were started 10 to 12 weeks after surgery. Standard anteroposterior, lateral and axillary views were taken immediately and then again at 6 weeks, 12 weeks, 6 months and 12 months following surgery (Figure 3). Post-operative anatomical reduction was seen mostly in patients with 2 part fracture. Callus formation and bridging trabecular bone were assessed in the follow-up radiographs for verification of radiological union. Functional evaluation of shoulder at final followup was done using Constant score [15]. The mean follow-up period was 18 months (range 12-36 months).

Results

Two patients were lost to follow-up. Of the remaining 20 patients, all fractures were united clinically and radiologically. The mean time for radiological union was 90 days {12 weeks (range 8-20 weeks)}. Early radiological union was seen with anatomical reduction (mean 87 days). At the final follow-up, the mean Constant score was 67.25 (range 50-100). Higher constant score was seen in 2 part (66.57) and 3 part (68.16) than four part (61.00) fractures. Patients who had trauma-surgery interval less than 5 days had mean constant score higher than those who had trauma- surgery interval more than 5 days. Patients operated early following trauma had more mean constant score and less blood loss. Patients who were mobilized early had better constant score than who had prolonged immobilization.

In our study, 50% patients had forward flexion possible up to 120 degree while 45% patients had more than 120 degree. 5% patients had less than 90 degree of forward flexion (table 3). In our study, 70% patients had abduction of up to 120 degree, among them 20% had less than 90%. 30% patient had abduction more than 20 degree (table 4). In our study, 50% patients had strength between 11-15 lbs, while 15% patients had strength between 16-20 lbs.

The results were excellent in 7 patients, good in 7 patients, fair

in 5 patients and poor in 1 patient. During hospital stay superficial infection were found in 2 patients and edema were found in 8 patients. Infection was treated with multiple debridements and intravenous antibiotics. During the follow-up, one case of varus malunion, four cases of stiffness and five cases of abductor weakness were noted. Patients with post-operative anatomical reduction did not have any late complications, while those having complications had non anatomical post-operative reduction. Other complications were not symptomatic enough to undergo additional surgery. No cases of avascular necrosis, hardware failure, locking screw loosening or non-union, failure of fixation were noted.

Discussion

Our study implies that treatment of proximal humerus fractures with PHILOS plate may give a satisfactory outcome. It allows early mobilization as the fixation is usually stable. An improved outcome requires precise knowledge and adequate surgical expertise. In addition, treatment of these fractures is challenging, especially in the elderly. Different techniques have been described for the fixation of comminuted and displaced proximal humerus fractures [7, 9, 10, 12]. All these techniques have been associated with a varying rate of complications such as cut-out or back-out of the screws and plates, nonunion, AVN, and fracture distal to the plate [13, 18, 20]. Locking periarticular plate fixation offers more advantages compared to many implants and have been shown to be superior to non-locking plates [20, 22]. Meticulous care must be taken to preserve the overlying soft tissues during open reduction and internal fixation since damage to these soft tissues may disturb the vascularity of fracture fragments [21, 23, 24].

In our study, we used the standard deltopectoral approach in all the patients. Important aspects of the surgical technique include placement of the plate in strict adherence to the technique, determination of appropriate length and placement of the screws with fluoroscopy, insertion of screws to the head in adequate number and position, providing medial cortex support for the prevention of varus displacement [26] and to fix tubercle fragments, fixation of the sutures passing through the junction of the tubercle and rotator cuff to the plate [25, 28]. In our study, overall complication rate was ~40%. The main complications were varus malunion in one patients, stiffness in four patients and abductor weakness in five patients. Egol *et al*. [27] observed only one case of acute infection in their series of 51 patients who mainly had 3- and 4-part fractures. Gardner *et al*. [23] reported superficial wound dehiscence in one patient and Moonot *et al.* [28] reported one superficial infection that healed with oral antibiotic treatment. Low incidence of infection in our study was attributed to meticulous surgical techniques and the special attention paid to soft tissue preservation. Humeral head screw penetration (0-23%) is noted in various studies [27, 29-32]. In our study, there was no such case. We executed intraoperative fluoroscopic monitoring of the drill bit while drilling and also monitored the screw position in two views to avoid articular penetration.

In the past, incidences of AVN have been reported in a wide range, 4%-75% of cases [23, 27, 33-36]. In our study we did not notice a single case. However follow-up was short term. More cases of AVN could potentially arise with longer observation [37, 38, 40]. Hertel *et al.* [39] evaluated risk factors for humeral head ischemia following intracapsular proximal humerus fracture and found that the most relevant predictors were the length of the dorsomedial metaphyseal extension (<8 mm), the integrity of the medial hinge (defined by greater than 2-mm shaft displacement in any direction), and fracture with an anatomic neck component (types 2, 9, 10, 11 and 12 in their binary description system). When three of these criteria were present, the positive predictive value for ischemia was 97%.

We did CT scans in 12 proximal Humerus fractures and measured dorsomedial metaphysical bony extension of humeral head along with integrity of medial hinge. In seven patients, dorsomedial metaphyseal bony extension was <8 mm and medial hinge integrity was lost in eight patients. Both these parameters along with intracapsular fracture extension were present in five patients. We did not find AVN even in this group of patients. We believe that a majority of humeral heads are quickly revascularised through creeping substitution. However we need a much longer follow-up period to come to any strong conclusions. Implant failure and loss of primary fixation of the implants occur in 2.7% to 13.7% of cases following open reduction and internal fixation with locking plates in proximal humeral fractures [14, 27-29].

In our study we did not noted such case of fixation failure. Varus malunion is one of the potential complications following fixation of proximal humeral fractures. It is defined as a head shaft angle of less than 120 degrees. Moonot *et al.* [28] reported the incidence of malunion in 3- and 4-part proximal humeral fractures. Björkenheim *et al.* [14] reported 26.3% of the fractures having 2-, 3- and 4-part united in slightly varus position after open reduction and internal fixation with locking plate. Agudelo *et al.* [29] considered primary varus reduction to be an important risk factor which may cause poor results. In our study we observed 1 case of varus malunion.

We did not notice nonunion and heterotopic ossification in our series. According to Constant score, excellent/good results accounted for 70%, and only 30% had fair/poor results. These results are comparable to those previously reported [41]. A relatively small sample size was the main limitation of this study. In conclusion, PHILOS provides stable fixation in proximal humerus fractures. Additionally, meticulous surgical dissection to preserve vascularity of humeral head is necessary to prevent potential complications such as AVN.

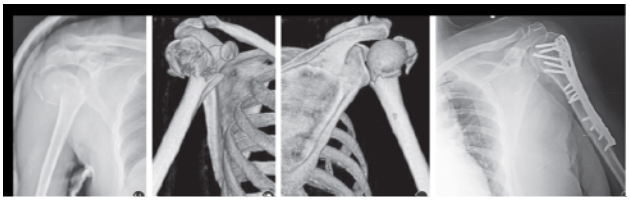


Fig 1: A, B, C: Preoperative radiograph and 3D reconstruction CT scans of a 40-year-old male patient who sustained 4-part fractures after road traffi c accident. **Fig 2:** Anteroposterior radiograph showing fracture at apex of PHILOS fi xed with DCP.

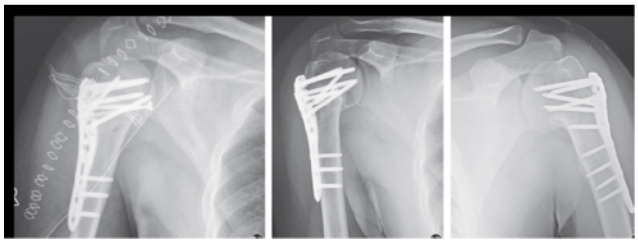
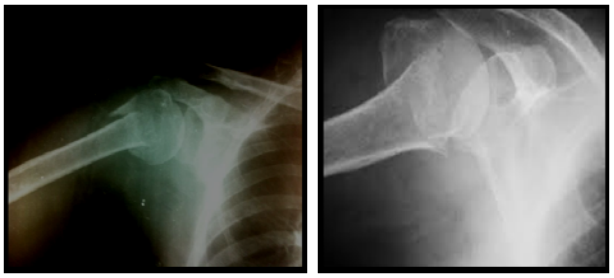


Fig 3: A: Immediate postoperative radiograph showing anatomic reduction of the fracture. **B:** Twelve months follow-up radiograph showing bony union. **Fig 4:** Anteroposterior radiograph showing varus malunion during the follow-up.

Clinical Photographs



Pre OP & Post OP X Rays

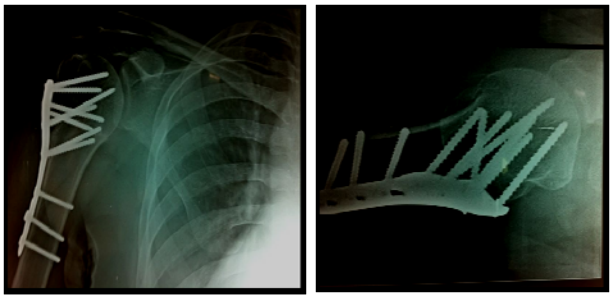


Table 1: Constant Score Constant scoring of 20 patients examined at six months of post-operative period was as under.

Constant Score	Number of patients in our study	Percentage (%)
10 to 20	00	00
21 to 30	00	00
31 to 40	00	00
41 to 50	01	05
51 to 60	05	25
61 to 70	07	35
71 to 80	06	30
81 to 90	01	05
91 to 100	00	00

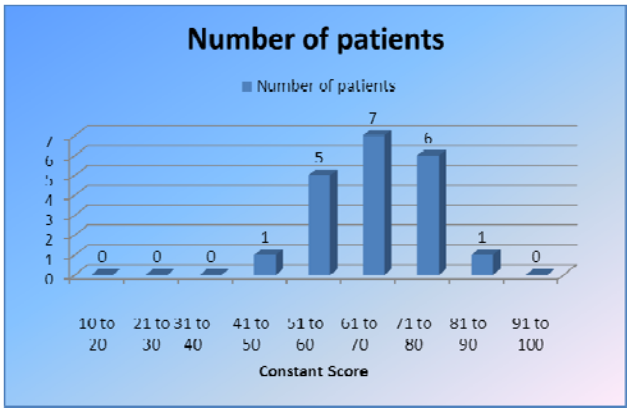


Table 2: Results

Constant score	Result
<50	Poor
51-60	Fair
61-70	Good
More than 71	Excellent

Result	No of Patients	Percentage (%)
Poor	1	5
Fair	5	25
Good	7	35
Excellent	7	35

The average score was 67.25 at six months.

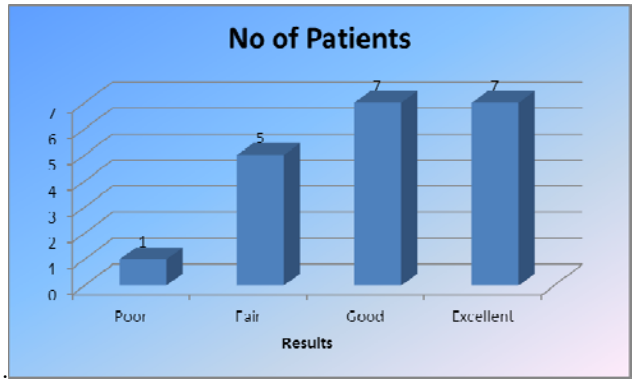


Table 3: Forward Flexion of Shoulder and Patients

Forward flexion degree	No of patients	Percentage
0-30°	00	00
31-60°	00	00
61-90°	01	05
91-120°	10	50
121-150°	09	45
151-180°	00	00

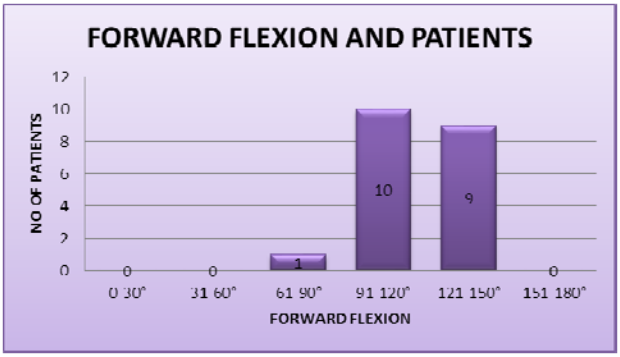


Table 4: Abduction of Shoulder and Patients

Abduction in degree	No of patients	Percentage
0-30°	00	00
31-60°	00	00
61-90°	04	20
91-120°	10	50
121-150°	06	30
151-180°	00	00

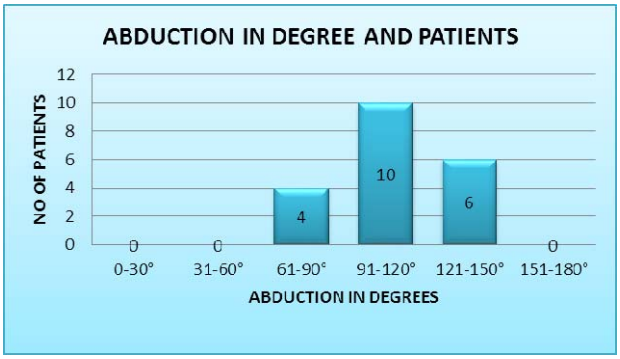


Table 5: External Rotation and Patients

External rotation	No of patients	Percentage
Not reaching the head	00	00
Hand behind head with elbow forward	00	00
Hand behind head with elbow back	02	10
Hand on top of head with elbow forward	11	55
Hand on top of head with elbow back	07	35
Full elevation from on top of head	00	00

Table 6: Internal Rotation and Patients

Internal rotation	No of patients	Percentage
End of the thumb to lateral thigh	00	00
End of the thumb to buttock	00	00
End of the thumb to lumbosacral junction	02	10
End of the thumb to L3 (waist)	10	50
End of the thumb to T12	05	25
End of the thumb to T7(interscapular)	03	15

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