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Original Research Article

Functional Outcome and Complications of Proximal Humerus Fractures Treated by Internal Locking Plate

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Abstract: ***Background:*** Proximal humerus fractures are commonly encountered fractures in general orthopaedic practices. Treatment should focus on maximizing a patient's functional outcome and minimizing pain. Various operative procedures are carried out, recent trend in internal fixation has moved on to locking plates which gives angular stability. ***Objective:*** The present study is undertaken to evaluate the functional outcome and complications of proximal humerus fractures treated by PHILOS locking plate. ***Methods:*** This prospective study was carried out at Department of Orthopaedic Surgery, BSMMU, Dhaka, Bangladesh from January 2015 to January 2016. Total 30 cases of fractures of proximal humerus were treated by open reduction and internal fixation with PHILOS locking plate and followed up. Patients were followed up in outpatient department at first, second, third and sixth months. Serial radiographs were taken for assessing complications and the functional outcomes were assessed using Constant and Murley score. ***Results:*** Total 30 cases of fractures of proximal humerus were treated by open reduction and internal fixation with PHILOS locking plate and followed up. In our study, male female incidence was equal with majority of patients sustaining fracture following road traffic accident. Average age of patients was 43±11.65 and most common fracture pattern observed in these patients were 3-part fracture (33.3%). 66% of the fractures united within three monthsand 94% of the fracture united within six months. Average constant score of 65.13 was achieved. Overall complication rates were 20% with one case of osteonecrosis of humeral head. 10% of the patient needed a second unplanned surgery. Fracture pattern and complications had significant impact on the functional outcome of the patient. ***Conclusion:*** Internal fixation with PHILOS plate is reliable operative option for displaced proximal humerus fracture which provides angular stable fixation, especially in an osteoporotic bone. High rate of complications depends both on implant design and operative technique. Therefore, attention on technical aspects of applying them would help optimization of the results.
Keywords: Proximal Humerus Fractures, PHILOS Plating, Complications.

INTRODUCTION

Proximal humerus fractures are commonly encountered fractures in general orthopaedic practices. Treatment should focus on maximizing a patient's functional outcome and minimizing pain. Understanding the functional anatomy of the proximal humerus as it relates to fracture is paramount to achieving these goals. Within the last three decades, the age-adjusted incidence of proximal humeral fractures increased by 15% per year. Increased incidence ofproximal humeral fractures is associated with more complications. Up to 80% of proximal humeral fractures can be treated nonoperatively, resulting in satisfactory results. [1] However, different techniques have been described for

fixation of comminuted and displaced proximal humeral fractures, including sutures, cerclage wires, K- wires, screws and plates, intramedullary devices, and shoulder arthroplasty. The complication rate can be as high as 50% or higher. [2,3] Intervention options range from nonoperative modalities to osteosynthesis, and in select cases arthroplasty. This paper will review relevant anatomy, common fixation constructs, appropriate indications for prosthetic replacement, and the authors' preferred treatment algorithm. Several complications have been reported, such as cut-out or back-out of the screws and plates, nonunion, avascular necrosis, nail migration, rotator cuff impairment and impingement syndrome. [4,5] Even shoulder arthroplasty in proximal humeral fractures may yield functionally poor results. [6] In order to decrease the incidence of complications, particularly fixation failure and loss of stability, and to improve stability and enable early post- operative mobilization, new plating techniques such as the Proximal Humeral Internal Locking System (PHILOS, Synthes, Solothurn, Switzerland) have been developed. [7] Since there is a high correlation between the holding capacity of screws and regional bone morphology (e.g. cortical thickness and bone mineral density), [8] Osteoporotic bone is implicated in the occurrence of complications in proximal humeral fractures. The aim of the present study was to evaluate the clinical results of PHILOS plate fixation in proximal humeral fractures and to analyze potential complications.

METHODOLOGY

This prospective study was carried out at Department of Orthopaedic Surgery, BSMMU, Dhaka, Bangladesh from January 2015 to January 2016. Total 30 cases of fractures of proximal humerus were treated by open reduction and internal fixation with PHILOS locking plate and followed up. Patients were followed up in outpatient department at first, second, third and sixth months. Serial radiographs were taken for assessing complications and the functional outcomes were assessed using Constant and Murley score. 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.

Inclusion Criteria

- Age group: 20 -60 years of age
- Closed fracture
- 2-part, 3 part and 4-part fracture
- fracture dislocation

Exclusion Criteria

- Undisplaced fracture
- Open fracture
- fracture more than 3 weeks
- severely comminuted fracture
- unfit for surgery
- Head injury
- Neurovascular injury
- Previous shoulder pathology

General information like name, age, sex, occupation and address were noted. Then detailed history regarding the mode of injury was elicited. History of the past illnesses were also elicited in detail. Clinical examination of the injured shoulder was done and neurovaslucar injury was ruled out. Other associated injuries were noted. Radiological evaluation was done and fracture of the proximal humerus was classified according to Neer classification. Blood investigation like haemoglobin, total count, differential count, ESR, random blood sugar, and ECG were done. Screening test were also done for all patient before surgery. All patients underwent apre-anesthetic check-up by the anesthetist and were operated as early as possible if general conditons were stable.

Preoperative preparations

- patients were kept nil per oral for 6 hours prior to surgery
- An informed consent for surgery was taken
- Systemic antibiotic (ceftriaxone sulbactam combination) was given one hour prior to surgery.

Operative Techniques

The choice of anesthesia was decided by the anesthetist and they have given both general anesthesia as well as regional block in combination. This helped to decrease the immediate post-operative pain.

Patient position and drape

Patients placed in supine position on operating table with wedge a sand bag under the spine and medial border of scapula to push the affected side forward while allowing the arm to fall backward. The entire shoulder girdle prepared including the proximal part of the arm, so that incision could be extended. Drape the arm free, because it will have to be moved during the approach.

Surgical approach

Deltopectoral approach- Incision starts just above the coracoid process, which is palpated in deepest point in the clavicular concavity distally towards acromioclavicular joint. An 8 to 10 cm incision started from just above coracoid process advanced following the line of deltapectoral groove. The intravenous plane is between the deltoid muscle which is supplied by axillary nerve and the pectoralis major muscle, which is supplied by the medial and lateral pectoral nerves. Retract pectoralis major medially and deltoid laterally, splitting the two muscle apart. The vein is retracted either medially or laterally. The short head of biceps and the coracobrachialis must be displaced medially before access can be gained to anterior aspect of shoulder joint. Beneath the tendons lie the transversely running fibers of

subscapularis muscle. Apply external rotation to the arm to stretch the subscapularis, bringing the muscle belly into wound and making its superior and inferior borders easier to define. Pass a blunt instrument between the capsule and the subscapularis, then divide the subscapularis in from insertion onto to the lesser trochanter of humerus. Incise the capsule longitudinally to enter the joint wherever the selected repair must be performed.

Procedure

Through delto-pectoral approach, the fracture was exposed and reduced with minimal soft tissue dissection. Briefly, the anatomical relationship between humeral head and greater tuberosity was reduced and fixed temporarily with K wires. In case of obvious rotation or displacement of the humeral head, a joystick technique was used. Then the shaft fragment was reduced by abduction, traction and rotation of the arm. Reduction was checked under image intensifier. Definitive fixation with locking plate was done with plate positioned lateral to bicipital groove sparing tendon of long head of biceps and 1cm distal to greater tuberosity. The screws were chosen according to preoperative planning, and all the four head screws were supposed to be inserted to the head fragment. The inferior screws supporting the humeral head were considered critical. Proximal locking screws were inserted to hold the humeral head, which are multi directional screws with the tips of the screws staying 5–10 mm away from the articular surface. All proximal locking screws were placed in a unicortical fashion through an external guide and confirmed to be within the humeral head with intra operative fluoroscopy. AP (internal and external rotation) view used to visualize screw placement. The distal shaft screws were placed bicortically. A minimum of three bicortical screws were used. Fluoroscopic images were taken to confirm satisfactory fracture reduction, plate positioning and proper length of screws in the humeral head. In case of severe comminution or instability, the rotator cuff, the greater tuberosity, and the lesser tuberosity were fastened to the plate using non-absorbable sutures. Range of motion of shoulder was checked on the table for impingement. Wound was closed under negative suction, which was removed after 48 hours.

Postoperative management

All patients are immobilized in arm pouch with cuff and collar sling. Appropriate antibiotics and analgesics were used. Immediate post operative radiographs were taken to determine the bone alignment and maintenance of reduction. Sutures removed by 10thday. Passive range of motion and pendulum exercises are begun immediately depending on pain. All patients were followed up at 4weeks, 8weeks, 12 weeks and at 6 months.

Exercise regime post PHILOS plating

From post-operative day one onwards patients are started on pendulum exercises with their arm pouch until the first follow-up visit in the op. During the first visit arm pouch was removed and started on active assisted external rotational to neutral. From two months onwards patients were allowed to have full range of movements.

Fracture Union

At first patients are clinically evaluated for fracture union. Then plain radiographs of shoulder are taken in anteroposterior and axillary views to decide on fracture union. If three out of four cortices shows bridging, fracture is considered as united. This is done on first, second, third and sixth month of follow up.

RESULTS

Total 30 cases of fractures of proximal humerus were treated by open reduction and internal fixation with PHILOS locking plate and followed up. Most of the excluded patients were above the age of sixty who were injured after a trivial fall. Therefore, first thirty patients with inclusion criteria were treated with open reduction and internal fixation with PHILOS plate. The mean age of all the patient in this study was found to be 43±11.65. The proximal humeral fracture was following a road traffic accident in 16(53%) patients, a fall from standing height in12(40%) patients and seizure in 2(6.66%) patients. 17 patients had injury to their dominant side. Dominant and non-dominant sides were equally affected. Gender distribution males were more involved. Out of the thirty patients, 26% sustained two-part fracture,33.3% had three-part fracture,16% had four-part fracture and 23.3% had fracture dislocation. The most common fracture type was 3-part fractures. The average hospital stay for patients were 8.2 days. At the one month, two-month, three month and six-month follow-up examinations, twenty nine out of thirty patients came for follow up. One of the patients in the study was lost in follow up.

During the follow up the Constant score improved significantly from the first month to the sixth month. The mean Constant score at 6th month of follow-up was 65.13±15.17. There was no statistically significant difference in the functional outcome of different age groups.

Out of the 30 patients, 8patients with 2-part fracture had an average constant score of 9 which was excellent. 10 patients had 3part fracture with an average constant score of 16 which was fair in outcome. 4part and fracture dislocation attained a lower constant score with good outcome.

This correlation indicated that, more complex the fracture, the function outcome was affected, and simple fracture had better functional outcome. The number of united fractures increased from 66 % at third month to 96% at the sixth month of follow up. There is astatistically significant difference in the union rates of different fracture types.

Six complications (20%) were encountered in Thirty study patients. Two patients had deep infection which was evident by 2nd month of follow up and required intravenous antibiotic and eventually implant was removed. Post surgery, one patient sustained brachial plexus injury. One patient had shoulder joint subluxation in the third month. One patient had avascular necrosis of humeral head which was evident in the 6th month of follow-up. In total, three (10%) patient had under gone second unplanned surgery within six months after first operation. Patient without any complications attained statistically significant higher Constant score than patients having any one of the complications. Patients with complications did not show statistically significant difference in union of fracture. Complications and duration for surgery did not show any association. But it showed 40% positive correlation.

Table-1: Age specific constant score

Age	Constant score				Total
	Excellent	Fair	Good	poor	
21-30	3	2	2	0	7
31-40	1	4	0	1	6
41-50	0	2	3	2	7
51-60	5	2	2	1	10
Total	**9**	**10**	**7**	**4**	**30**

Pearson Chi-Square value is 11.7; p value = 0.227
There was statistically significant association between fracture type and functional outcome.

Table 2: relationship between types of fracture and average constant score

Types of fracture part	No. of cases	Percentage	Average constant score	Inference
2 part	8	26%	9	excellent
3 part	10	33.3%	16	Fair
4 part	5	16%	23	good
Dislocation	7	23%	28	good
Total	**30**	**100%**	**76**	

Table-3: Neer classification of the study patients

Neer classification	Union in Weeks				Total
	8	12	24	>24	
1	2	3	3	0	8
2	3	7	0	0	10
3	0	5	0	0	5
4	1	1	3	2	7
Total	**6**	**16**	**6**	**2**	**30**

Pearson Chi-Square value is 19.27; p value = 0.023

Table-4: Complications of the study patients

Complication	Frequency	Percent
Nill	24	80.0
Yes	6	20.0
Total	**30**	**100.0**

Table-5: Functional outcome of the study patients

Complication	Functional outcome				Total
	Excellent	Fair	Good	poor	
0	9	9	5	1	24
1	0	1	2	3	6
Total	**9**	**10**	**7**	**4**	**30**

Pearson Chi-Square; 10.72 p value is 0.013

Table-6: Complications and difference in union of fracture

	Fracture union at 6th month	

Complication	Nonunion	Union	Total
No	0	24	24
Yes	2	4	6
Total	**1**	**28**	**30**

Fisher's Exact Test; p value is 0.0759

Table-7: Complications and duration for surgery

	Time in minutes					Total
Complication	<90	90-120	121-150	150-180	>180	
No	1	7	11	2	3	24
Yes	0	1	0	2	3	6
Total	**1**	**8**	**11**	**4**	**6**	**30**

Pearson Chi-Square 8.9; p value 0.063 Spearman Correlation + 0.40

DISCUSSION

A Finnish research group estimated that proximal humerus fractures represent an increasing challenge to the health care system due to the increasing proportion of elderly people in the population.[9] The majority of patients suffering from these fractures are over 60 years old, and most proximal humerus fractures in this population are associated with osteoporosis.[10] Nevertheless, stable reduction is essential for fracture healing and early return of shoulder function. For patients with osteoporotic bones or comminuted fractures, surgical stabilization is difficult, and the treatment of displaced, unstable fractures remains controversial. Various techniques, including intramedullary nailing, plate-and-screw osteosynthesis, tension straps, percutaneous pin fixation, and hemiarthroplasty, have been used to stabilize proximal humerus fractures.[11-13] Successful results have been reported after plate osteosynthesis for proximal humerus fractures.[13-15] Open reduction and internal fixation of proximal humerus fractures with nonlocking plates and screws has been shown to provide the strongest fixation in nonosteoporotic bone.[11] In this study, the mean age of patients at the time of injury was 48 years. Because the stability of osteosynthesis using nonlocking plates and screws relies on friction between the plate and bone, the effectiveness of conventional plate-and-screw fixation decreases as bone quality improves. Furthermore, complications such as screw loosening due to poor screw retention in osteoporotic bone result in high failure rates, especially in patients with three- and four-part fractures. Kristiansen and Christensen [8] reported satisfactory or excellent results in only nine of twenty patients who had fixation of a proximal humeral fracture with a T-buttress plate, and there was a high rate of fixation failure. The authors stated that the results for all four-part fractures were poor and recommended primary treatment with a prosthesis. New techniques involving the use of plates and screws with angular stability have been introduced in order to avoid these complications. The Locking Proximal Humerus Plate was designed to maintain a stable fracture reduction even in osteoporotic bone. Advantages of the Locking Proximal Humerus Plate include gentlefracture reduction with use of indirect maneuvers, a high resistance to avulsion even in patients with poor bone stock because of the combination of fixed-angle screw-plate locking and three-dimensional placement of screws in the humeral head, and the possibility of early exercise and a short period of immobilization because of the high initial stability achieved. [9] The mean age of patients with proximal humerus fracture in our study was 43±11.65 which is not comparable with other studies done previously. The mean age of patients in most of the other studies were more than sixty since this is a fracture of elderly. [14-17] We included only patients below the age of sixty because wewanted to avoid skewing in the measured results due to osteoporosis. In our study there was male preponderance, while most of the other studies had female preponderance.[14-17] This is due to the fact that female is predisposed to osteoporosis whom we did not include in ourstudy. One study concluded that female patients were significantly older than male patients while we could notfind any relations in gender age and its incidences. Patients sustaining fracture following high energy trauma were higher compared to other studies in which most of the fracture were following low energy trauma like fall from standing height. [14-17] 53% of our patients had fracture following road traffic accident while its only 13 to 25%in other studies. Variation may be due to the exclusion of patients above the age of sixty. Two patients had fractures following seizure episodes which was not reported in any other studies. We could not find any significant difference between the incidence of fracture in dominant and non-dominant sides. According to Neer classification, 26% two part, 33.3% three part, 16% four-part fractures and 23.3% fracture dislocation was found. Study by Felix Brunner et al had similar incidences except for fracture dislocation which was 5% in their study. Most of the patients in our study had a high energy trauma which might be the reason for higher incidence of fracture dislocation compared to other studies. The most common fracture type was 3-part fractures which was consistent with other studies. [17] The mean time between injury and surgery was 2.76 days and did not have any significant influence over the functional outcome of the patients. This was consistent with other studies. Average interval between fracture and surgery was 2.9 days in Felix Burnner et al study. The mean time taken for ORIF was 150.5 minutes. This longer surgery time compared to other studies may be due to the higher

incidence of fracture dislocation in our study. No statistically significant association was found between surgery time and complications. Although our study population consisted patients with mostly complex fracture patterns, the incidence of secondary displacement, pseudarthrosis, or osteonecrosis complications was relatively low compared with previously performed studies concerning the treatment of proximal humerus fractures. 66% of the fracture united within 3 months and 94% of the fracture united within 6 months. We observed six complications (20%) inthirty patients during the six months of follow-up. There is very high variation between the studies in terms of incidence of complications. Felix brunner et al and Plecko et al [18] detected 33% and 34% complications respectively in patients with PHILOS plate. One study mentioned that patients over the age of sixty were at a significant 1.9 times higher incidence of experiencing any complications compared to young patients. [19] The patients score improved once the implant was removed. The main challenge in the operative treatment of proximal humeral fractures is to achieve effective stabilization of an adequately reduced fracture in order to maximize the functional outcome. The locking of the screws onto the plate prevents the screws from backing out. Therefore, if the fracture collapses, the screws may penetrate thearticular surface. This penetration may be more likely if the screws are placed very close to the articular surface or if the articular surface was penetrated during drilling. The most common complications reported in most of the other studies were screw perforation either primary or secondary. [15,16] The working groups of Kettler et al [20] and Charalambous et al [21] detected 24/176 and 2/17 primary screw perforations, respectively, in their series of PHILOS plate patients. Most of these patients were over the age of sixty which we did not include. Avascular necrosis is the one of the most feared complications following open reduction internal fixation of proximal humerus fractures. AVN can develop as long as five years after injury. [22] This phenomenon is supported by the observation that studies with longer follow up usually also report higher rates of AVN. Inour study we had one patient with avascular necrosis which was diagnosed at sixth month followup. [23] The incidence of AVN varies from 0-68% throughout the literature. [24,25] The fracture type itself, the length of the dorsomedial metaphyseal extension, and the integrity of the medial hinge were found to be the most relevant predictors of humeral head necrosis. This is supported by a study by Jost et al. [26] presenting a AVN rate of 68% including only three- and four-part fractures. But in our study, we could not find a relation between fracture type and occurrence of AVN. The Constant score for AVN patient was 66. Sharafeldin et al [27] reported that few patients with radiographic evidence of AVN had a good or excellent Constant score compared to those with AVN.

CONCLUSION

The advantage of this fixation is that it allows early postoperative mobilization of the affected shoulder and leads to a better functional outcome of the affected shoulder compared to conservative treatment, which immobilizes the patient's affected shoulder for a long period of time. Among the 30 patients 6(20%) had complications, and 3 had unplanned second surgery. The PHILOS Proximal Humerus Internal Locking System, in combination with divergent or convergent screw orientation, significantly increases resistance to pull-out and fixation failure. While traditional plate systems rely on compression between the underside of the plate and the bone for stability, this is not the case with PHILOS. This reduces the risk of thread stripping in osteoporotic bone, as the plate-bone interface is not stressed along the screw axis. This allows for a more biological fixation as compression of the underlying periosteum and blood supply to the fracture area is significantly reduced. In summary, the angular stability of the PHILOS locking plate allows for early mobilization, making it the preferred implant in proximal humerus fractures, especially comminuted fractures in younger patients.

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