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Long Term Results of Proximal Humerus Locking Plate

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Introduction

Proximal humeral fractures are the third most common fractures after hip and distal radius in elderly population. They constitute about 4-5% of all fractures[1], but, the majorities of them are minimally displaced and can be successfully treated non-operatively with early rehabilitation[2], but displaced fractures require anatomical reduction with internal fixation[3].

Despite general agreement that complex fractures should be treated operatively, no consensus exists on the type of surgical technique. Closed reduction and percutaneous pinning,[4] tension band wiring,[5] intramedullary nailing,[6] plate fixation[7] and hemiarthroplasty[8] have demonstrated mixed results. Closed reductions of comminuted fractures are difficult to maintain. Three- and 4-part fractures in healthy, active patients are typically treated with surgery to optimize shoulder function[2] but, it includes extensive surgical exposure and damage to vascular supply of bone fragments.

Defining appropriate treatment protocols is further complicated by poor reproducibility and reliability of the commonly used classification system devised by Neer[2]. The AO/Association for the Study of Internal Fixation (AO/ASIF) classification system[9] also has been shown to be insufficiently reproducible.

Several new locked plate devices have been developed because research suggests plates with attached (locked) screws may provide improved fracture stability and healing.[10] Locking the screw to the plate mechanically recreates a point of cortical bone contact[11] which may be useful in the poor cancellous bone of the proximal humerus. Locking plates also have a preconfigured shape and screw direction, which may reduce hardware complications. Early clinical results using the locking proximal humerus plates have been promising.[12,13]

The aim of this retrospective review to assess long term results of displaced proximal humeral fractures treated with the Proximal Humerus locking Plate (PHLP) at our institution.

Material and Methods

The Retrospective Study was performed from September 2011 to Feb 2014 at the orthopaedics Department. P.D.U. Hospital, Rajkot .Gujrat , India, with average follow up period was 21.49 months (12-38 months). There were 20 women and 25 men with a mean age of 61.6 years (19 to 86). Out of a total of 45 patients, 25 were found to be older than 65 years of age suggesting a strong relation of proximal humerus with age related osteoporosis. 25 of the patients sustained their injury following a fall, 19 from a road traffic accident and 1 from direct assault.

All patients evaluated Anteroposterior (AP) and axillary plain radiographs of the shoulder obtained at the time of injury, postfixation, and at most recent follow-up to classify the fracture and measure the fracture displacement and head–neck angle. Computed tomography (CT) scans were used in few complex fractures.

The proximal humerus fracture was classified by the AO/Orthopaedic Trauma Association system[9] (Table 1). There were 12 type IIA (2-part), 20 type IIB fractures (3-part), and 13 type IIC fractures (4-part). All fractures met the indications for operative treatment outlined by Neer et al[14], i.e. an angulation of the articular surface of more than 45 degrees' or displacement between the major fracture fragments of more than 1cm. It is protocol maintain to treat some fracture-dislocations (particularly in the physiologically elderly), head-splitting fractures, and impression fractures that involve over 40% of the articular surface with a hemiarthroplasty.

	>65 years old	<65 years old
AO-OTA Type A	7	5
AO-OTA Type B	11	9
AO-OTA Type C	7	6
Total	25	20

Table 1. Distribution of fracture types according to age groups

The intraoperative variables studied from OT Records like, operative time, estimated blood loss, No. of units of blood transfused and other complications related to implants. Anesthesia was decided by consultant anesthetist.

Operative Technique:

All cases were performed by a senior orthopaedic surgeon. Patients received prophylactic intravenous antibiotics. Most of patients were placed in the supine position and the C-arm was positioned parallel to the patient at the head of the bed. Satisfactory imaging was ensured before prepping the patient. A delto-pectoral approach was used with minimal soft tissue dissection. The biceps tendon was identified and retracted, and the fracture exposed. On occasion the biceps tendon was found to be interposed in the fracture fragments requiring mobilisation. Traction sutures were then placed around the tendon-bone interfaces of the rotator cuff

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and tuberosity fragments. The head fragment, when involved, was then reduced from its typical varus position through manipulation and flexing of the arm. Once in position the traction sutures were used to bring the fragments beneath the head to buttress the articular fragment. The facture was then held temporarily with K wires and the reduction checked fluoroscopically. The traction sutures were then passed through the proximal eyelets on the plate without any tension. The PHLP was then applied lateral to the bicipital groove, 1-2cm distal to the upper end of the greater tuberosity. A conventional non-locking screw was then inserted into the slotted gliding hole on the plate this both brings the plate to the bone and allows for minor adjustments in plate height and position when checked on fluoroscopy. The polyaxial locking screws were inserted into the head, and locking screws were also inserted into the shaft. The arm was placed in a sling after wound closure. Using the immediate anteroposterior post-operative radiograph the humeral neck-shaft angle was determined. The anatomic neck-shaft angle of the humerus varies from 130 to 140 degrees.

First dressing and removal of negative suction was done after 72 hrs post op. 2nd dressing was done at day 5 and patient discharged from the hospital if there is no evidence of infection. Stitch removal was done on 14th day at Hospital and reassessed for infection. Outpatient follow up was carried out at 1 month, 3 month, 6month and year. Pendular exercises only were permitted for the first 4 weeks post-operatively, with elbow and wrist range of motion also encouraged. Passive progressing to active range of motion was then commenced under the guidance of a physiotherapist at 4-6 weeks post-op. Resistive strengthening was begun when fracture union was ensured.

All postoperative complications were recorded. Routinely, clinical and radiographic examinations were performed four to six weeks and three months after surgery. In our study, average follow-up period is 21.5 months. At the most recent follow-up, shoulder range of motion (ROM) and strength was evaluated by the neutral person and recorded. Standard anteroposterior, axillary and lateral radiographs fracture healing, non-union, malunion, loosening of implant, loss of reduction and avascular necrosis of head of humerus. The criteria for radiographic healing were when all fragments showed substantial cortical continuity. Functional outcome assessed with Constant-Murley score[15]. The Constant score was graded as poor (0-55 points), moderate (56-70), good (71-85) or excellent (86-100). To access for the potential effect of learning curve on the outcome, we arbitrarily divided the patients into two categories; patients operated by us in or before December 2012 and patients operated by us in or after January 2013.

Results

The mean operative time was 81 minutes (range, 60-123) and the mean blood loss was 222 millilitres (range, 150-600). Data for forward flexion, abduction, and external rotation were available for 18 of 25 the patients (78%). Internal rotation was reported too infrequently for meaningful analysis. At recent follow up, Mean forward flexion was 123^0, mean abduction was 110^0, and mean external rotation. Abduction and external rotation not significantly improved as it may be due to extensive surgical dissection.

Type A (n=12)	Type B (n=20)	Type C (n=13)	All Type (n=45)	P Value
77.54 ± 10.21 (64-92)	73.22 ± 10.67 (52-92)	66.00 ± 12.61 (42-86)	72.08 ± 11.77 (42-92)	0.039*

*** Significant**

Table 2 Constant score at last follow up according to fracture type (AO-OTA type)

Table 2 and table 3 shows Constant scores of the patients at the final follow up visit according to fracture types and age respectively. We found that patients with Type A fractures had the highest Constant scores while patients with Type C had the lowest Constant scores and these results were found to be statistically significant (p value 0.039). The Constant scores were found to be higher in younger patients as compared to older patients and this result was also found to be statistically significant (p value = 0.12). Overall the functional outcome was found to be moderate to excellent in 88.88% of our patients. However, almost 11.11% patients had poor outcome. These results are shown in table 4. Various complications seen in our study have been shown in table 5.

>65 years old (n = 25)	<65 years old (n = 20)	All (n = 45)	P Value
68.51 + 11.44 (42-88)	76.90 + 10.67 (52-92)	72.08 ± 11.77 (42-92)	0.013*

*** Significant**

Table 3 Constant score at at follow up visits according to the age of patient

	Excellent	Good	Moderate	Poor	Total
Total	5	20	15	5	45
AO-OTA Types (A/B/C)	2/2/1	5/10/5	5/6/4	0/2/3	12/20/13
Age (<65 yrs/ >65 yrs)	2/3	9/11	7/8	2/3	20/25
Percentage	11.11%	44.44%	33.33%	11.11%	100%

*** Significant**

Table 4 Functional outcome on the basis of Constant score at the last follow up visit

Various complications seen in our study have been shown in table 6.

Complications	No. of patients	Prior cases*	Late cases**
Non-union/Delayed union	0	0	0
Screw back out or failure of fixation	4	3	1
Subacromial impingement	5	4	1
Axillary nerve palsy	2	1	1
Superficial wound infection	5	3	2
Deep wound infection	4	3	1
Symptomatic AVN humeral head	2	0	2

*** Prior Dec 2012 ** After jan 2013**

Table 5 Various complications seen in our study

The fracture displacement between the inferior edge of the head fragment and the adjacent medial edge of the shaft fragment was measured on the initial anteroposterior

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shoulder radiograph. The initial head–shaft fracture displacement was 26 mm on average (range, 5-76 mm). All fractures united with an average union time of 20 (16-25) weeks. A varus head shaft axis on immediate postoperative Xrays and at last follow up visit was found to be a strong predictor of poor Constant score. However a valgus alignment was found to have no effect on the final Constant score. This result is highlighted in table 6.

	Immediate postoperative (no.)	Last follow up (no.)	Constant score at last follow up
Normal	38	37	73.05 ± 12.01
Major Varus (<120°)	2 5	5	63.60 ± 12.44
Major Valgus (>160°)	7 5	5	73.40 ± 6.38

Table 6 Comparison of head shaft axis with mean Constant score at follow up

We also found that patients operated by us earlier (before Dec 2013) had somewhat inferior Constant scores at follow up as compared to the patients operated by us later on (after Jan 2014). A higher number of complications were also seen in the patients operated by us earlier. These results are highlighted in table 5 and table 7.

	Cases done earlier	Cases done later on	P value
Number	18	27	
AO-OTA types (A/B/C)	7/4/7	5/16/6	
Mean Constant score	68.31 ± 13.47	74.64 ± 9.92	0.082**
No. of complications	14	8	

**** trend towards significance**

Table 7 Comparison of the cases operated by us earlier (before Dec 2013) as compared to the cases done later (after Jan 2014)

Discussion

Proximal humerus fracture is the most common fracture of the shoulder. It is the second most common site of fracture in the upper limb after distal radius. The literature describes many options for treatment of displaced proximal humeral fractures.[4-8] Treatment focuses on the displaced fracture fragments, since these may have limited vascularity and may benefit from reduction and fixation. Using the Neer's classification, >85% of all proximal humerus fractures are 1-part fractures that should heal successfully after a brief period of sling immobilization followed by early physical therapy within 14 days of injury.[1] In our retrospective study, we focused on displaced or high-energy 2-, 3-, and 4-part fractures. In elderly patients fragility of the bone complicates the pattern fracture. These patients also have comorbidities which makes the treatment of these patients even more challenging.

If we analyze the results of other technique, Neer[2] originallyStableforth[3] followed by Flatow et al[5] experienced up to 90% satisfactory results with a suture tension band technique in three part fractures and up to 100% 2 part fractures. Although this has worked effectively in older patients, it may be less reliable in younger patients with complex high-energy fractures or multiple extremity injuries. Kristiansen and Christensen[22] reported only 45% satisfactory results according to Neer criteria using an AO T plate for 3-part fractures. Paavolainen et al[23] obtained 63% satisfactory results using the same technique by positioning the T plate more inferiorly on the greater tuberosity to avoid "impingement" on the acromion; however, they still encountered intra-articular screw placement. In an attempt to avoid hardware-related complications of the T plate, Esser[7] used a cloverleaf plate and was able to obtain 92% satisfactory results with a contoured cloverleaf plate.

Björkenheim et al[16] reported the results of 72 elderly patients (mean age, 67 years) with isolated proximal humerus fractures treated with the Locking Compression Plate. Thirty-six patients (50%) achieved a good or excellent Constant score at 1-year follow-up, with reduced scores in elderly patients and those with type C fractures. There were 3 cases of osteonecrosis and 2 nonunions, but 19 fractures (26%) developed varus malalignment. Initial varus malreduction has been noted to increase the risk of fracture fixation failure.[17-19] Fankhauser et al[20] noted loss of proximal screw fixation and varus malalignment in 10% of cases. They recommended augmenting the proximal fixation with sutures placed through the rotator cuff and attached to the Locking Compression Plate. So, early clinical results using the Proximal Humerus locking Plate have been promising, though not without complications.[17,18]

The results of our study showed good or excellent outcomes in around 56% of our patients. These results were somehow inferior to those reported in the western literature. Patients operated by us earlier shows somewhat inferior results as compared to those operated later and this result showed a trend towards significance (p = 0.082) on Chi square analysis. Also a higher number of complications were seen in the patients operated by us prior. This leads us to believe that application of locking plate technology for proximal humerus fractures has a steep learning curve and appropriate surgical technique is very important for achieve good functional outcome. We also found inferior results with AO-OTA type 3 fractures which are expected as these fractures are more complex and open reduction and internal fixation is tougher. The results were also inferior in patients with age older than 65 years. Neverthless our results in older age patients are better than those of traditional plates used in such osteoporotic fractures[7]. We, thus believe, that a locking plate device for proximal humerus fractures gives a satisfactory outcome in most of the patients including those with old the age and poor bone density.

As it was a large series, various complications were encountered by us. Varus malalignment (head shaft angel < 120°) was noted immediately postoperatively in 2 of our patients, 3 more in further follow up patients showed varus collapse. Subsequent loss of reduction was seen in all five of these patients. None of the patients with a neutral or valgus alignment had a loss of fixation at long term follow up. We thus found that a varus malalignment was a strong predictor of loss of fixation. Most of the complications in our series occurred during our initial experience (table 5).

No case of non union or delayed union was seen. There were 2 cases of axillary nerve palsy required no intervention. Symptomatic humeral head AVN was noted in 2 patients with Type C fractures at follow up visits. Both of them were later operated with hemiarthroplasty and the result was found to be good. We encountered subacromial impingement to start within 5 of our patients. Deep wound

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infection was seen in 3 patients. 2 of these settled after debridement surgeries but one needs implant removal, although it was reoperated later after infection had settled. However superficial wound infection seen in 5 patients, settled with an extended course of IV antibiotics and local wound treatment.

In our present study, proximal humerus locking plate has shown promising result in displaced and comminuted proximal humeral fractures. Trends were noted toward improved fracture reduction (mean displacement, 2.5 mm) and valgus head–neck alignment (mean, 142.1°) in the proximal humerus locking plate, which could be advantageous for fracture healing.[17] The ROM of all patients (mean forward flexion, 123°; mean abduction, 110°; mean external rotation, 45°).However, our data did not establish a relationship between better fracture alignment and ROM or functional outcome. Loss of reduction occurred in 10% of patients (5 patients) after implant loosening in proximal fragments. Varus malreduction has been found to be a predictor of such of reduction and must be avoided intraoperatively at every cost.

A limitation of our study was the absence of a control group treated by a different modality. Thus we cannot actually determine if any other method of treatment would have led to different results. Nevertheless our results are better than those of the previous studies in which plate osteosynthesis other than locking plate has been used[7]. Also the significant sample size (45 patients) and adequate average follow up period (21.5 months) could be strength of our study.

Conclusion

In the present study it was believe that Proximal humeral locking plate provides an excellent stable construct even in multi fragmented osteoporotic proximal humerus fractures as well as satisfactory functional outcome over long term follow up in most of the patients. Although the results are less satisfactory in elderly patients with osteoporosis and AO-OTA type C fractures have poorer results as compared to type A or type B fractures, as well. However the results in type C fracture are good enough to recommend open reduction and internal fixation with locking plates in these patients. A varus malalignment may powerful indicator of loss of fixation and should be avoided when possible. One might face few complications initially because surgery carries sharp learning curve. However, strict adheres to principles and a meticulous soft tissue handling with aggressive post operative rehabilitation ensures a satisfactory long term functional outcome.

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