

Outcome Analysis of Locking Plate Fixation in Proximal Humerus Fracture

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ABSTRACT

Introduction: Proximal humerus fractures account for approximately 5% of all fractures. Stable minimally displaced fractures can be treated nonoperatively but the management of displaced fractures remain controversial with various modalities of treatment available. Locking plates provide stable fixation and enable early postoperative mobilization specially in osteoporotic proximal humerus fracture.

Aim: To evaluate the functional outcome of locking plate fixation and to compare the results of two approaches used for fixation.

Materials and Methods: This prospective study was conducted at a tertiary level hospital between September 2011 to December 2013. PHILOS plates were used for internal fixation of displaced proximal humerus fractures Neer's type 2 part, 3 part and 4 part fractures on 26 patients (M/F ratio 1.36:1; mean age 46 years). According to Neer classification, 5,12 and 9 patients had displaced 2, 3 and 4 part fractures respectively. Deltopectoral and deltoid splitting approaches were used for fixation on 13 patients each. Functional outcome was assessed using Constant-Murley shoulder score. Graphpad software version 6.0 was used with Chi-square test and Fisher-exact test are used to compare data. The p-value < 0.05 is considered significant.

Results: Of the 26 patients, all fractures united radiologically and clinically and average constant score at final follow-up was 72.5. At the final follow-up 8 patients had good score, 10 patients had moderate score, 6 patients had excellent outcome and 2 patients had poor outcome according to Constant score. Mean time to union was 12.3 weeks (9–15 weeks). Four complications (15.4%) were encountered, 2 cases of varus malunion, 1 case of wound infection which required wound debridement and 1 case of screw cut-out in which screw removal was done. Mean constant score in delto splitting approach was 70.9 and 74 in deltopectoral group (p-value= 0.54). No significant difference existed in constant score in 2 approaches. No significant difference existed between groups in terms of complications (P > .05) and all fractures were united.

Conclusion: Our study demonstrates that locking plate fixation gives good functional outcomes in treatment of proximal humerus fractures. There was no significant difference in the two approaches used for exposure. Our results are comparable to various studies conducted by other authors which states that locking plates provide better functional and radiological outcomes as compared to other fixation methods like Tension band wiring, percutaneous K-wire fixation, non-locking plates, intramedullary nails.

Keywords: Approach, Complication, Constant score, Osteoporosis

INTRODUCTION

Proximal humerus fractures comprise upto 4-5% of all fractures [1,2] and they are the most common of humerus fractures (45%). The increased incidence of proximal humerus fracture in older population is related to osteoporosis [3]. Proximal humerus fractures are the 3rd most common fracture in elderly patients [4,5]. Due to osteoporotic bones, fixation of proximal humerus fractures especially in the elderly patients is difficult and is associated with high complication rates [3].

Most common mechanism of injury is fall on an outstretched hand typically in older osteoporotic women. Younger patients typically present with proximal humerus fracture following high energy trauma such as motor vehicle accident [6]. An 80% of proximal humeral fractures are non or minimally displaced fractures - can be treated non-operatively [6]. Non operative treatment and fixation using K-wires lead to stiffness and decreased range of motion [7-9].

Optimal treatment of displaced or unstable fractures remains controversial. Various techniques, including open reduction and internal fixation with proximal humeral plates, intramedullary nailing, percutaneous or minimally invasive techniques with pins or screws and arthroplasty, have been described in literature [7,10-13]. Proximal Humerus Internal Locking System (PHILOS)

plate was designed to provide angular stability especially in osteoporotic bones and to decrease the high complication rates associated with these fractures [8,9,11,14,15]. Non-locking plates like T-plates and cloverleaf plates have high failure rate in weak osteopenic bones and complication rates of upto 40% which includes subacromial impingement, screw loosening and avascular necrosis [16,17]. Various studies have reported no benefit of Tension Band wiring used in treatment of proximal humerus fractures [18,19]. Blade plates were later introduced which were a more rigid construct than previously used conventional plates but due to their larger profile and insufficient hold in osteoporotic bones, these plates have high failure rates [20]. Load sharing devices like intramedullary nails have reduced lever arm but due to insufficient purchase of proximal screws, were associated with high complication rates (31%) [21]. Loosening or backing out of the proximal screw was the most common complication seen. Results were satisfactory mainly in two part proximal humerus fractures [21,22].

Locking plates were designed giving consideration to the anatomy of proximal humerus. These plates have low profile and are biomechanically better suited for fixation of proximal humerus fracture [23]. They provide angular stability and locking screw anchorage in weak osteoporotic bones [24]. In addition to multiple locking screws, these plates also have small holes to fix rotator cuff

with sutures or cerclage wires. This plate also provides multiple locking screw options which can be inserted in convergent/divergent fashion for better pull-out strength [23,25]. Locking plates are being widely used now for fixation of proximal humerus fractures due to low complication rates [24-30].

Current study was undertaken to assess the functional outcome and complications associated with PHILOS plate used for treating displaced proximal humerus fracture and to compare the results of two approaches used for exposure.

MATERIALS AND METHODS

This was a prospective study conducted at a tertiary level hospital, from September 2011 to December 2013, on 26 patients with fractures of the proximal humerus. These patients were managed with PHILOS plate. All fractures were classified as per the criteria of Neer classification [31] (a part is defined as displaced more than 1cm or with an angulation of more than 45°). Study inclusion criteria were non compound fractures of proximal humerus in skeletally mature patients (18-70 years), fractures of proximal humerus Neer type 2,3,4 and fractures of the proximal humerus which are less than 1 month old. Exclusion criteria were pseudoarthrosis, pathological fracture, refracture, open fracture, fracture more than one-month-old and associated post-traumatic brachial plexus injury or peripheral nerve palsy.

All fractures were classified by single experienced trauma surgeon using plain radiographs (anteroposterior and transscapular view). Surgery was performed through a deltopectoral approach in 13 patients and through an anterolateral deltoid-splitting approach in 13 patients [Table/Fig-1]. The cases were operated by two Professors of the department (having a minimum 20 years of experience in the field of orthopaedics). Random allocation was done for every case, on alternate basis; with first case falling into deltoid splitting group and second case into deltopectoral and then third into deltoid splitting and henceforth. Each professor is attached to separate units and this pattern of randomisation was followed in these two units.

Postoperative Protocol

Three doses of intravenous antibiotics (first generation cephalosporin) were given to all the patients with first dose preoperatively and other two doses postoperatively. Shoulder pendulum, active assisted and passive exercises were started on first postoperative day. Active shoulder exercises were started once fracture union was evident on radiographs. Early mobilisation reduces pain in postoperative period and also motivates the patient to continue physiotherapy when discharged.

Clinical and radiographic evaluation

Functional assessment was done using Constant shoulder score [32]. Follow-up done at 1st, 3rd, 6th, & 12th weeks, 6 month and thereafter. The constant score was graded as poor (0-55 points), moderate (56-70), good (71-85), excellent (86-100). Radiographs were taken at each follow-up to evaluate fracture union and any complication like fracture displacement, loss of reduction or varus-valgus angulation was also noted. Failure was defined as backing out of the screw, plate breakage /pull-out, malunion, nonunion or avascular necrosis of humeral head. At final follow-up patients were evaluated by Constant score and radiographs were taken to assess for union or any complication mentioned above. Callus formation, presence of bridging osseous trabeculae and cortical continuity were considered as evidence of radiological union. Humeral head-shaft angle is the angle between humeral shaft axis and head. Head axis was taken as perpendicular to a line between the nearest lateral and medial points of the anatomic neck through the apex of the head. Head-shaft angle was further categorized as major varus (115 degrees), minor varus (115–124 degrees),

normal (125–145 degrees), minor valgus (146–155 degrees), and major valgus (155 degrees) and compared between the immediate postoperative and last follow-up radiographs.

STATISTICAL ANALYSIS

Statistical analysis was performed using Graphpad software version 6.0 by statistical consultant with level of significance being 0.05. Chi-square test and Fisher-exact test was used to compare the results between two groups.

RESULTS

The mean age of the patients in the present study was 46 years with minimum age patient of 22 year and maximum of 68 year. The male:female ratio was 1.36:1 with male predominance. Right upper extremity was involved more commonly with the ratio being 1.16:1 which was due to right handedness of the majority of the population. The predominant mode of injury was due to fall (53.8%) followed by road traffic accident (46.2%). The time interval between the injury and operation was approximately 7 days. The majority of fractures in the present study were Neer's type 3 part (46.1%), followed by 4 part (34.7%) [Table/Fig-1]. Minimum number of patients was those with 2 part fracture (19.2%).

Of the 26 patients, all fractures united radiologically and clinically. No patient was lost to follow-up. Mean time to union was 12.3 weeks (9 –15 weeks) and mean constant score at final follow-up was 72.5. At the final follow-up 8 patients had good score, 10 patients had moderate score, 6 patients had excellent outcome and 2 patients had poor outcome according to constant score. Age-wise average constant score distribution is shown in [Table/Fig-2]. We compared the results in 2 part, 3 part and 4 part fracture types as per Constant score and time to union. Average Constant score in 2 part fracture was 80.8, in 3 part was 71.3, and in 4 part was 69.3 [Table/Fig-3]. There was no significant difference in outcomes between patients with 3-part and 4-part fractures (p-value=0.6). Constant score decreased as the degree of comminution increased. Radiographs of a patient of two part proximal humerus fracture showing good fracture union is shown in [Table/Fig-4]. Although proximal humerus fracture has maximum age incidence in elderly osteoporotic bone but in present study maximum number of cases were in age group 50-60 years

Neer Classification	Total No. of Cases (n)	Deltoid Splitting Approach	Deltopectoral Approach
2 Part	5	2	3
3 Part	12	7	5
4 Part	9	4	5
Total	26	13	13

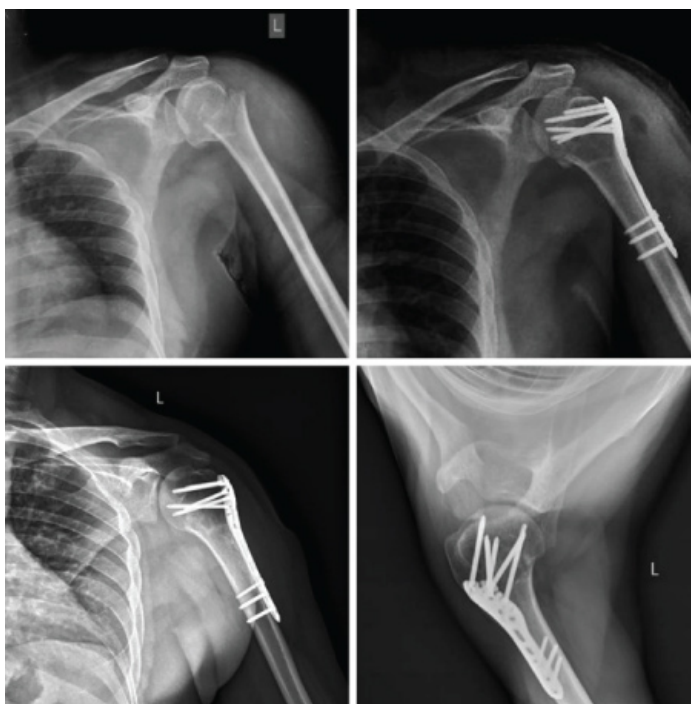
[Table/Fig-1]: Evaluation on basis of age group of patients and average of constant shoulder score.

Age (Yrs)	Total No. of Patients (n)	Constant Shoulder Score
20-30	4	84
30-40	5	67.2
40-50	3	74
50-60	10	72.2
60-70	4	67

[Table/Fig-2]: Distribution of cases as per neer classification and approaches used.

Neer Type	Deltoid Splitting Group	Deltopectoral Group	Avg Constant Shoulder Score of Neer Type
2 Part	79	82	80.8
3 Part	70.6	74	71.3
4 Part	67.5	70.8	69.3
Total	70.9	74	72.5

[Table/Fig-3]: Evaluation on basis of neer type and constant shoulder score.



[Table/Fig-4]: Preoperative, immediate postoperative, follow-up anteroposterior and lateral radiograph at 1 year of 2 part proximal humerus fracture of 24-year-male showing good union.



[Table/Fig-5]: Preoperative, immediate postoperative, follow-up anteroposterior radiograph at 6 months and 18 months of 3 part proximal humerus fracture in 50-year-male showing varus malunion.

and least in 60-70 years. During the follow-up, 4 complications (15.4%) were encountered, 2 cases of varus malunion (minor varus), 1 case of wound infection and 1 case of screw cut-out. Two cases required reoperation, one patient had wound infection at 5th postoperative day for which debridement was done and the other had screw cut out at 8 weeks post surgery for which screw removal was done. These fractures healed uneventfully after debridement and screw removal. Other two cases healed in varus malunion but were asymptomatic.

Twenty six patients were treated by PHILOS plate with 13 patients was operated by deltopectoral and 13 patients by deltoid splitting approach. Mean Constant score in deltosplitting approach was 70.9 and 74 in deltopectoral group (p -value= 0.54) [Table/Fig-3]. No significant difference existed in Constant score in 2 approaches. The average time to union in Deltoid splitting approach was 12.1

weeks (9 – 15 weeks) and in Deltopectoral approach was 12.6 weeks (9 – 15 weeks). However, when compare the composite score in reference with age group (<50 and >50), the difference between the group was significant ($p=.032$) between two groups on basis of Nonparametric Mann Whitney Score. Clinical examination at follow-up revealed no evidence of axillary nerve palsy such as atrophy or loss of weakness in either group. One early-onset wound infection in deltopectoral group, none occurred in the deltoid-splitting group ($p=0.29$) was treated successfully by debridement and antibiotic therapy. One screw cut-out occurred in the deltopectoral group, which required a surgery to remove the screw. There were two cases with varus malunion (8%) [Table/Fig-5], 1(3.8%) in the deltoid-splitting group and 1(3.8%) in the deltopectoral group. However, no significant difference existed between groups in terms of complications ($p>0.05$) and all fractures were united.

DISCUSSION

The present study aimed at evaluating clinical outcome after PHILOS plate fixation and to evaluate the potential complications during the follow-up period. The early results of PHILOS plate fixation have been reported in the study. This study also supports the hypothesis that surgical approach for plate fixation has no crucial influence on outcome.

Patients with proximal humerus fractures have been on the rise in the past few decades due to increase in the proportion of population with osteoporosis as the age advances. It has been shown in various studies that osteoporosis adversely affects the anchorage of internal fixation and leads to increased failure rates [33,34]. Patients who have 3 part or 4 part proximal humerus fractures, are more prone for poor clinical results and high failure rates especially when the fixation has been performed with conventional non-locking plates [17,35].

Various fixation methods have been used in the past for treatment of proximal humeral fractures which showed variable outcomes. In a study by Sadowski et al., fixation with PlantTan plates resulted in 100% complications especially in elderly osteoporotic bones, with penetration of the proximal screw being the most common complication [36]. Various studies have reported outcomes similar to non-operative group in patients treated with Tension band wiring [18,19]. Similarly, AO-T plates and cloverleaf plates were shown to give poor results in osteoporotic bones [16,17]. Complications like screw loosening, subacromian impingement and avascular necrosis of upto 40% has been reported with these plates [16,17]. Polarus nail was later introduced for treatment of these fractures [21,37] but a high complication rate was seen (proximal screw loosening, revision surgery and lateral metaphyseal comminution predisposing to implant failure) [38].

Locking plates provide better stability than conventional plates that were used in the past [39-41]. Many authors have demonstrated that they give better functional outcome and also avoid complications [1,9,11,42-44]. Because of this the use of locking plates has become the standard protocol for open reduction and internal fixation of proximal humerus fractures particularly in the elderly patients with poor bone quality [9,11,44]. Besides this, the functional outcome also depends upon the stability provided by the implant. In the locking plate system, all the forces are transmitted from the bone via the Locking head screws to the blade and vice versa. Hence, the fixed angle plates enable a gain in the torsional stiffness and stability and may therefore promote a superior outcome and less chance of complications like cut-out of the screws and plates, non-union, avascular necrosis, and fractures distal to the plate [45].

In this study, mean constant score at the final follow-up was 72.5. The average time to union was 12.3 weeks (9–15 weeks). The average time to union in Deltoid splitting approach was 12.1

weeks (9-15 weeks) and in Deltopectoral approach was 12.6 weeks (9 – 15 weeks). Average time to union in 2 part fractures was 11.2 weeks, in 3 part it was 12.5 weeks and in 4 part 12.6 weeks. Complications (screw cut out, varus malunion, infection) occurred in total 4 cases (15.4%).

In a study conducted by the Frankhauser et al., proximal humerus fractures were treated with Locking Proximal Humerus Plate (LPHP) [11]. They observed no non-union and reported a low incidence of re-operations (n=2), the Mean Constant – Murley score was 74.6 after 12 months. Björkenheim et al., in their study reviewed 72 patients treated with Locking Compression plate [9]. At final follow-up, 36 patients reported excellent outcome. A total of 31 patients reported moderate outcome and 5 patients had poor results. Koukakis et al., reviewed 20 patients in their study and showed favourable results with surgical treatment of proximal humerus fractures using a Locking Compression Plate [44]. After a mean follow-up of 16 months, the mean constant score was 76.1 the results did not differ significantly with age but in our study younger patients had better outcome. Hente et al., studied 31 patients with displaced 3-part and 4-part fractures of the proximal humerus treated with Locking Compression Plate [46]. After a mean follow-up period of 18.5 months, the mean constant score was 76.

Present series had complication rate similar to the study conducted by Martinez et al., which after a follow-up of 58 patients had no case of wound infection, avascular necrosis, or loss of fixation, only 2 patients (3.44%) had axillary nerve palsy which recovered spontaneously in 3 months and 5 patients complained of impingement symptoms (8.62%) [47]. Similarly, in a prospective study by Roderer et al., implant related complications (plate impingement, screw perforation, loosening of screw) were seen in 9 cases (17%) [48]. Study conducted by Nourozi et al., had similar outcome with 15% complication rate in a study conducted in 37 patients with 1 case of AVN, 2 case of wound infection and 3 case of malunion [49]. According to Charalambous et al., out of 25 cases, 5 required revision because of implant failure or non-union [50]. Out of 25 implants, 4 had screw protrusion into the glenohumeral joint, 4 had screw loosening and backing out, and 1 plate broke without further trauma [50]. PHILOS is an effective system for stabilizing these fractures but the potential complications should also be taken care of. In another study, Rose et al., reported 0 infections, 4 nonunions, and 0 cases of AVN in 16 patients at 12-month follow-up [51].

Two major approaches have been described for the surgical management of proximal humerus fractures. The Delto-pectoral approach is the procedure of choice [52,53]. However, several surgeons agree that this approach may not be the best option when performing an angular stable plate fixation of a proximal humerus fracture [53-57]. However, it involves substantial soft-tissue dissections, including partial release of the deltoid muscle, retraction of the deltoid muscle and the humeral manipulation to access the lateral aspect of humerus. As a result it becomes difficult to gain the correct drill angle using a standard Delto-Pectoral approach. Therefore this approach is not the best when performing an angular stable plate fixation of a proximal humeral fracture [58,59]. Recently the Deltoid Splitting approach has become more popular. It is a minimally invasive approach used for the osteosynthesis of proximal humeral fractures in a sliding-in technique. Plating through a minimally invasive anterolateral acromial approach allows the direct access to the appropriate plating zone, a bare spot between the humeral head-penetrating vessels from the anterior and posterior circumflex artery. Further this approach prevents deltoid release and also avoids exposure of anterior blood supply and thus will prevent devitalisation of fracture fragments [60].

The current study showed no difference in outcome in fracture proximal humerus treated with locking plate in deltoid splitting and deltopectoral group in terms of Constant score and complications. Constant score of 74 in deltopectoral and 70.9 in deltosplitting group are comparable in both the groups and with other studies also. Previously, possibility of axillary nerve during plate fixation through deltoid splitting approach is been seen as a limitation of this approach [55,61-64] but in the current study no axillary nerve palsy was noted. Laflamme et al., Hepp et al., [65,66], Gardener et al., also found no lesions to the axillary nerve [55,57].

LIMITATION

There are two major limitations to this study. First, the number of patients was less and the mean time to follow-up was short. We suggest a large sample size and longer follow-up period will further validate the results obtained here in.

CONCLUSION

PHILOS plate fixation gives good functional outcomes in proximal humerus fractures with early mobilisation. Our study has shown no significant differences between the two approaches. Also there was no high predisposition to axillary nerve injury seen with deltoid splitting approach.

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