ORIGINAL ARTICLE

To Detect the Outcome of Proximal Humerus Fractures Treated With a Locking Proximal Humerus Plate

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ABSTRACT

Aim: To evaluate the safety, usefulness, and practical outcome of the locked proximal humerus plate (LPHP) to treat proximal humerus fractures.
Setting: Patel hospital Karachi, Indus Hospital Karachi and Civil Hospital Karachi.
Methods: Over a 08 month period, 64 consecutive patients were treated with a LPHP for an unstable or displaced proximal humerus fracture. Demographic data, trauma mechanisms, surgical approaches, and postoperative complications were collected from medical records. Fracture classification according to the Neer classification, radiographic head–shaft angle, and screw tip–articular surface distance in true anteroposterior and axillary lateral radio-graphs of the shoulder were measured postoperatively. The functional outcome was evaluated with a Constant–Murley (CM) evaluation. The CM score is a validated shoulder-specific scoring system in which patients report subjective findings. The physician reported the objective measurements of the shoulder.
Results: Follow-ups were completed for all of the patients. The overall complication rate was 3 5.9%, with screw penetration into the gleno humeral joint as the most frequent problem (7.6%). Deep wound infections were observed in 2(1%) of the cases and avascular necrosis in 2(1%). All complications occurred in 4-part fractures. Subacromial impingement, frozen shoulder, rotator cuff rupture, and wound dehiscence were observed in 2(1%), 2(1%), 1(6%), and 1(6%) of the cases, respectively. Multivariate linear regression analysis revealed that the fracture pattern and the presence or absence of medial support were significant predictors of functional outcome (P=0.026 and P=0.003, respectively). Patient age (P=0.58 1), sex (P=0.325), and initial tuberosity displacement (varus/extension or valgus/impaction; P= 0.059) were not significantly associated with the CM score.
Conclusions: The LPHP seems to be a promising implant for the fixation of proximal humerus fractures. However, there are certain limitations that should be mentioned. The number of cases in our study was small, and no safe conclusions can be extracted regarding the rate of avascular necrosis. Additional studies with larger cohorts and longer follow-ups are necessary to better define the appropriate indications for and expected outcomes of this technology.
Keywords: Humerus fracture, locking, plate

INTRODUCTION

Fractures of the proximal humerus account for 4%–5% of all fractures. Because of the growing elderly population, they are being seen with increasing frequency. 1–3 The majority of these fractures are nondisplaced and can be managed conservatively.[3,4] However, displaced fractures may require open reduction and internal fixation to achieve fracture stability and early mobilization of the shoulder and upper extremities.

The locking proximal humerus plate is a relatively new implant; designed for the fixation of proximal humeral fractures.[5] It combines the principles of conventional plate fixation with locking screws. The locked interface also provides fixed stability, which helps to prevent subsidence in the metaphyseal areas[6,7,8]

PATIENTS AND METHODS

We included all of the adult patients that had displaced proximal humeral fractures. The indication for operating on these fractures in each case was a displaced fracture of the proximal one-third of the humerus. All patients with open injuries, preexisting nerve injuries, multiple injuries, or pathologic fractures were excluded. There were 5 patients with minimally displaced 2-part fractures who were treated conservatively and 4 patients with 4-part fractures who were treated with a hemi arthroplasty during this period of time.

Preoperative true anteroposterior (AP), scapular lateral, and axillary X-rays of the shoulder were reviewed at each center to determine the fracture type. The fracture type was recorded in the operative

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report. The fracture patterns were classified according to the Neer[9] and OTA Classifications. Surgical indications included all 3-part and 4-part fractures, and 2-part fractures with approximately 100% displacement or varus mal-alignment with medial cortical comminution that were deemed to be unstable by the treating surgeon. The extent of medial comminution was specifically noted. Fragment mobilization was achieved indirectly with the use of nonabsorbable sutures placed through the rotator cuff tendons, adjacent to the displaced tuberosity fragments. In all cases, the humeral head was elevated and reduced through a lateral cortical window. The tuberosities were then reduced, and the plate was applied to the lateral aspect of the humeral shaft, just lateral to the bicipital groove. All proximal locking screws were placed through an external guide and confirmed to be within the humeral head via intraoperative fluoroscopy. AP (internal and external rotation) views and axillary views perpendicular to each other were used to visualize the screw placement. The distal shaft screws were placed bicortically and were a combination of locked and nonlocked screws. The number of screws used within the proximal and distal segments was left to the discretion of the treating surgeon.

After surgery, all patients were treated with a similar postoperative rehabilitation protocol that emphasized early passive and active motion exercises. Isometric deltoid, biceps, and triceps strengthening exercises were begun immediately on the first postoperative day. Patients were fit with a sling and were encouraged to start early passive range of motion exercises.

Initial consultation included assessment of the axillary nerve motor and sensory functions. Computed tomography scans were obtained at the discretion of the treating surgeon. Radiographic evaluation was performed to identify union, mal-union, implant-loosening, and implant-related complications. Using the best AP projection radiograph following union, the neck–shaft angle was measured for all fractures that united. For those fractures classified as a malunion, the neck–shaft angle was also assessed in the final intraoperative or first postoperative films to determine whether mal-union was the result of poor initial reduction or postoperative fracture displacement. The presence of pain due to some other obvious cause such as protruding screws or adhesive capsulitis did not exclude the diagnosis of union. Nonunion was defined as a failure of union to occur within 6 months postfixation. Mal-union was defined as healing of the fracture with a neck/shaft angle of less than 120~ or more than 145~ on an AP radiograph. Loss of fixation included varus collapse with or without intra-articular penetration of the screws, bone–plate disengagement, and fracture of the plate or screws. Avascular necrosis was diagnosed according to the Association Research Circulation Osseous international classification staging system.[11] All cases were then subdivided into 1 of 2 groups according to the presence or absence of medial mechanical support of the proximal humeral head fragment. If this support was present, the fracture was considered to have adequate medial support (+MS group); fractures that did not fulfill this criteria were designated as having inadequate medial support (MS group), as previously described by Gardner et al[12].

Statistical Analysis: Statistical analysis was performed with the statistical program SPSS version 16.0. Continuous outcome variables were analyzed using Student t-test. Discrete variables were analyzed with the chi-square test or Fisher exact test. Group outcome data were analyzed using a Mann–Whitney test (Wilcoxon rank-sum test).

RESULTS

Thirty-four patients were considered to have MS and were designated as part of the +MS group. The 30 remaining patients were in the –MS group. The demographics of the 2 groups (+MS group and –MS group) were comparable, and there was no difference between the 2 groups with regard to age, sex, Neer fracture type, OTA fracture type, or injury mechanism (Table 1). The +MS group had an overall mean CM of 81 at the last follow-up (12 months), higher than the –MS group mean of 65 (P = 0.002). The strength and range of motion portions of the CM were higher for the +MS group than for the –MS group (P = 0.035 and P = 0.004, respectively), whereas there was no difference between the 2 groups for the pain and activities of daily living portions of the CM. The CM outcome data for the 2 groups are summarized in Table 2.

In 64 LPHP fixations, the fractures united. Five patients required revision surgery. The mean neck shaft angle was 126.5~ (range 101~–143~), with 3 mal-unions. All patients with tuberosity mal-union were older than 65 years old, had osteopenia, and had poor functional outcomes at the last follow-up.

At the final follow-up, 3 of the patients had an excellent functional outcome, 28 patients had a good score, 29 patients had a moderate score, and 4 patients had a poor outcome, according to the CM score. From the follow-up at 3 months to the final follow-up at 1 year, the mean CM scores increased from 70 to 88 in the 2-part fracture group, from 51 to 80 in the 3-part fracture group, and from 45 to 63 in the 4-part fracture group. A repeated-measures analysis of variance with a covariate (age) was used to investigate the functional outcome, as measured by the CM score, in different fracture types at the 3-, 6-, 9-, and 12-month follow-ups. A difference among the 3 different fracture groups (2-part, 3-part, and 4-part groups) was found, controlling for the effects of time and age (P = 0.037), and a difference among the different ages (.60 years old and = 60 years old), controlling for the effects of time and fracture type (P=0.002), a significant difference among the 4 time points, controlling for the effects of fracture type and age (P=0.001), and a difference among the 3 different fracture groups over time (P=0.021;Table 3).

Table 1: Patient characteristics of both groups

	+MS	-MS	P
N	34	30	
Gender			0.155
Male	10(29.4%)	14(46.7%)	
Female	24(70.6%)	16(53.3%)	
Age (Yr)*	61+12	65+9	0.326
Neer fracture classification			0.884
2	5 (14.7%)	3 (10.0%)	
3	17(50%)	15 (50.0%)	
4	12(35.3%)	12 (40.0%)	
OTA fracture classification 0.993† Type A			
2.2	1(2.9)	1(3.3)	
3.1	1(2.9)	1(3.3)	
3.2	3(8.8)	1(3.3)	
Type B			
1.3	4(11.8)	4(13.3)	
2.1	5(14.7)	4(13.3)	
2.2	8(23.5)	7(23.3)	
Type C			
2.3	4(11.8)	5(16.7)	
3.2	8(23.5)	7(23.3)	
Injury mechanism			0.836
Body height fall	20(58.8%)	17 (56.7%)	
Road traffic accident	7 (20.6%)	8 (26.7%)	
Fall downstairs	7(20.6%)	5(16.7%)	

The most frequent complication that occurred in this study was screw penetration into the glenohumeral joint after fracture collapse. Five patients (7.8%) had screws that penetrated the humeral head, and all underwent removal of the penetrating screws. No nerve or vascular injuries were observed. Deep wound infections were observed in 2(1%) of the cases, and avascular necrosis was observed in 2(1%) all of these cases were 4-part fractures. Subacromial impingement, frozen shoulder, rotator cuff rupture, and wound dehiscence were observed in 2(1%), 2(1%), 1(6%) and 1(6%) of the cases respectively.

Table 2: The CM score of the 2 groups at the last follow-up

	+MS	**-MS**	**P(MW)**
Total score	81±8	65± 6	0.002
Pain	13±1	12±1	0.436
Power	20±3	15±3	0.035
Range of motion	30± 5	22±4	0.004
ADL	17±1	15±1	0.182

Table 3: The Results of Repeated Measures Analysis of Variance with covariate (age) on functional outcome in different fracture types of the CM scores at 3-, 6-, 9-, and 12-month follow-up

Fracture Type

Follow-Up	**2-Part**	**3-Part**	**4-Part**
3 months	70±7	51±6	45±9
6 months	81±5	72±4	55±7
9 months	82±8	75±6	56±5
12 months	88± 6	80±4	63±7

P*

Effect of Fracture Type	0.037
Effect of age	0.002
Effect of time	0.001
Interaction between fracture type and time	0.021
Interaction between age and time	0.236

The fracture types were classified according to the Neer classification.

*The effect of fracture type denotes the difference among the 3 different fracture groups (2-part, 3-part, and 4-part groups), with values at the control of effects of time and age; the effect of age denotes the difference among the different ages.

DISCUSSION

Proximal humerus fractures are becoming more prevalent in societies with increasingly older populations. These fractures are not simple to treat. A variety of options are available; however, outcomes are less than ideal in many patients.[7] Optimal fixation of proximal humeral fractures remains challenging. The goal of proximal humerus fracture fixation is to obtain an anatomic reduction, mechanical stability, and early range of motion, whereas preserving the humeral head's blood supply[14]. Locking plate technology has been developed as a potential solution to the difficulties encountered in using conventional plating to treat fractures in osteoporotic bone, particularly with metaphyseal comminution. The key to this technology is the fixed-angle relationship between the screws and plate. The threaded screw heads are locked into the threaded plate holes to prevent screw toggle, sliding, and pull-out, thus diminishing the possibility of primary or secondary loss of reduction[15].

The clinical outcomes and complication rates observed in this study are similar to those of previous reports. Fankhauser et al[16] reported on a series of patients treated with proximal humerus locking plates. Twenty-nine shoulders with proximal humerus fractures (5 arbeitsgemeinschaft fuer osteo-synthesefragen association for the study of internal fixation type A, 15 type B, 9 type C) were evaluated at a minimum 1-year follow-up using CM scores and plain radiographs. The mean CM score for all patients at 1 year was 74.6 (type A, 82.6; type B, 78.3; type C, 64.6). Four patients had redislocation; one fracture was associated with a deep infection. Three patients had varus mal-union in which the screws cut through the humeral head; in 2 of these patients, subacromial impingement developed because the plate was positioned too proximally. Only 2 of the 29 patients in the study had partial osteonecrosis of the humeral head. In one patient, the plate fractured before fracture healing, necessitating revision surgery.

Koukakis et al[17] published a study of 20 patients with 2-, 3-, and 4-part fractures treated with proximal humerus locking plates. The authors stressed the importance of anatomical reduction of the fracture and correct surgical technique[17]. The repeated-measures analysis of variance with a covariate (age) was used to investigate the functional outcome, as measured by the CM score, in different fracture types at the follow-ups. It was found that age, fracture type, and time from surgery influenced the functional outcomes. In addition, there was a difference among the three different fracture groups over time. However, only the fracture pattern and the presence or absence of MS was significant predictors of functional outcome according to a multivariate linear regression analysis. Patient age, sex, and initial tuberosity displacement (varus/ extension or valgus/impaction) were not significantly associated with the CM scores. Previous studies have linked age[17,18] sex[18], osteoporosis[19], varus subsidence of the humeral head[20], screw perforation, and implant cut-out and MS[12] to outcomes with a LPHP.

Five patients had screws that penetrated the humeral head in the current study. Care should be taken to avoid head penetration and subsequent chondrolysis with proximal interlocking screws. Fracture collapse likely caused many of the cases of screw penetration[23]. Gardner et al recently showed that mechanical support in the inferomedial region of the proximal humerus is important to maintain fracture reduction and minimize forces at the screw–bone interface.[12] Therefore, achieving adequate MS may have decreased the rate of this complication. Another possible solution to this problem could be to pack calcium phosphate cement into the defect at the fracture site to increase mechanical support before plate and screw placement. Screw penetration missed at the time of surgery, although a possibility, is unlikely because AP (internal and external rotation) views and perpendicular axillary views were used to visualize the screw placement[10].

In our experience, the application of the LPHP is no more difficult than that of other devices previously used in our department. The main challenge is achieving an anatomic reduction of the fracture, especially in 3-part and 4-part fractures. An anatomic reduction is even more difficult to achieve in older fractures due to callus formation and fibrous tissue interposition. In these cases, it was particularly difficult to identify and preserve the biceps tendon, which is used as a landmark in the identification of the greater and lesser tuberosity fragments. An interesting outcome of this study was the relatively low incidence of osteonecrosis, a much-feared complication of plate fixation that can result from the fracture pattern itself or from soft tissue dissection used in operative treatment[5]. At the same time, the incidence of osteonecrosis for 4-part fractures and unclassified complex fractures in our studies is 21% and 75%, respectively[27] The low overall rate of this complication in this study may be due to the surgical technique and soft tissue preservation made possible by a fixed-angle construct, especially the preservation of the anterior circumflex humeral artery and its branches[5].

There are several limitations to this study. First, our study included 3 surgeons performing the procedures. The individual learning curve associated with the performance of a new procedure or use of a new implant may have influenced the results of the study. Second, the functional outcomes were evaluated only with the CM evaluation. This evaluation has limitations; other methods (e.g., the disabilities of the arm, shoulder and hand evaluation[29]) should be performed together with it to better evaluate the clinical outcomes of applying the LPHP technique. Third, there was no control group of patients treated either nonoperatively or with an alternative device. Patients were selected to receive operative fixation on the basis of the severity of their clinical and radiographic presentation. It would have been unethical to randomize patients into nonoperative treatment unless it was indicated. Fourth, the decision to treat patients operatively and use the LPHP was at the discretion and judgment of the treating surgeon.

CONCLUSION

In conclusion, the LPHP seems to be an adequate device for the fixation of proximal humerus fractures. Achieving mechanical support of the inferomedial region of the proximal humerus seems to be important for maintaining strength and range of motion in the shoulders of patients treated with this device. Additional studies with larger cohorts and longer follow-ups are necessary to better define the appropriate indications for and expected outcomes of this technology.

REFERENCES

1. Lind T, Kroner K, Jensen J. The epidemiology of fractures of the proximal humerus. Arch Orthop Trauma Surg. 1989;108:285–287.
2. Helmy N, Hintermann B. New trends in the treatment of proximal humerus fractures. CORR. 2006;442:100–108.
3. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006;37:691–697.
4. Zyto K. Non-operative treatment of comminuted fractures of the proximal humerus in elderly patients. Injury. 1998;29:349–352.
5. Haidukewych GJ. Innovations in locking plate technology. JAm Acad Orthop Surg. 2004;12:205–212.
6. Gautier E, Sommer C.Guidelines for the clinical application of the LCP. Injury. 2003;34(Suppl 2):B63–B76.
7. Nho SJ, Brophy RH, Barker JU, et al. Innovations in the management of displaced proximal humerus fractures. JAm Acad Orthop Surg. 2007;15: 12–26.
8. Rose PS, Adams CR, Torchia ME, et al. Locking plate fixation for proximal humeral fractures: initial results with a new implant. JShoulder Elbow Surg. 2007;16:202–207.
9. Neer CS 2nd. Four-segment classification of proximal humeral fractures: purpose and reliable use. J Shoulder Elbow Surg. 2002;1 1:389–400.
10. Robinson CM, Page RS. Severely impacted valgus proximal humeral fractures. Results of operative treatment. JBone Joint SurgAm. 2003;85: 1647–1655.
11. Sakai T, Sugano N, Nishii T, et al. Extent of osteonecrosis on MRI predicts humeral head collapse. Clin Orthop Relat Res. 2008;466:1074–1080.
12. Gardner MJ, Weil Y, Barker JU, et al. The importance of medial support in locked plating of proximal humerus fractures. J Orthop Trauma. 2007;21: 185–191.
13. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res. 1987;214:160–164.
14. Fakler JK, Hogan C, Heyde CE, et al. Current concepts in the treatment of proximal humeral fractures. Orthopedics. 2008;31:42–51.
15. Wagner M. General principles for the clinical use of the LCP. Injury. 2003; 34(Suppl 2):B31–B42.
16. Fankhauser F, Boldin C, Schippinger G, et al. A new locking plate for unstable fractures of the proximal humerus. Clin Orthop Relat Res. 2005; 430:176–181.
17. Koukakis A, Apostolou CD, Taneja T, et al. Fixation of proximal humerus fractures using the PHILOS plate: early experience. Clin Orthop Relat Res. 2006;442:115–120.
18. Shahid R, Mushtaq A, Northover J, et al. Outcome of proximal humerus fractures treated by PHILOS plate internal fixation. Experience of a district general hospital. Acta Orthop Belg. 2008;74:602–608.
19. Solberg BD, Moon CN, Franco DP, et al. Locked plating of 3- and 4-part proximal humerus fractures in older patients: the effect of initial fracture pattern on outcome. J Orthop Trauma. 2009;23:113–119.
20. Agudelo J, Schu¨ rmann M, Stahel P, et al. Analysis of efficacy and failure in proximal humerus fractures treated with locking plates. J Orthop Trauma. 2007;21:676–681.